R. B. TULLER

MECHANICAL DENTISTRY.

A

PRACTICAL TREATISE

ON

MECHANICAL DENTISTRY.

BY

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Second Edition, very much Enlarged,

WITH

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TO

JAMES TAYLOR M.D., D.D.S.,

EMERITUS PROFESSOR OF THE INSTITUTES OF DENTAL SCIENCE IN THE OHIO COLLEGE OF DENTAL SURGERY,

AS AN

ACKNOWLEDGMENT OF PROFESSIONAL EMINENCE AND PRIVATE WORTH,

This Volume is gratefully inscribed,

BY

HIS FRIEND AND FORMER PUPIL,

THE AUTHOR.

PREFACE TO SECOND EDITION.

The exhaustion of a large edition of the present work under circumstances which have, in a marked degree, affected the sale of all similar publications adversely within the past eight years, and the assurance of its favorable acceptance by the profession, conveyed in the various friendly, impartial, and generally commendatory notices which greeted its first appearance, afford adequate encouragement for the preparation of a second edition, which, it is hoped, will, in a still greater degree, commend itself to the favorable consideration of the profession.

Aiming, in the first instance, to make this treatise a distinctly practical guide to the manipulations of the dental laboratory, discarding everything, in point of facts or modes of practice, which was not well grounded in theory and confirmed by experience, the Author finds but little embraced in the first, which it is deemed necessary to exclude from the second, edition. Some verbal corrections and changes of phraseology have been made, and numerous interpolations and additions of matter introduced throughout the body of the work, while other portions have been almost entirely re-written.

The chapter on *Vulcanite Base* has been so revised and extended as to comprehend all that is valuable and approved

in that particular process, and will, it is believed, be found to be as comprehensive and reliable in text and illustration as any description of the method yet published.

In the initial portion of the chapter devoted to *Artificial Dentures with Continuous Gums*, the practitioner and student will be gratified to find descriptions of this unrivalled process from the pen of its distinguished Author himself, embracing a concise and intelligible account of the various modes of procedure employed at this time by Dr. Allen.

The Author's special and grateful acknowledgments are due to Prof. Norman W. Kingsley for the able, comprehensive, and highly instructive contribution on *Artificial Vela and Palates*, which appears at the close of the volume. The accompanying illustrations, explanatory of the text, derive additional value from having been executed under his own immediate supervision, and will, it is believed, convey a more satisfactory and intelligible understanding of the mechanism of the apparata employed by him, than any heretofore imparted by published descriptions.

An additional chapter has been embodied in the work, embracing all the information of a practical character that could be obtained in reference to the working of Aluminium as a base for artificial teeth.

Processes in a stage of but partial or incomplete development have not been treated of for the reason that it is judged inconsistent with the design and character of a work like the present to embrace descriptions of immatured methods or modes of manipulation, the practicability of which has not been ascertained, or the merits of which have not been passed upon or confirmed by the common experi-

ence of the profession. Time must be given to sanction or condemn whatever does not at present stand approved.

In the preparation of the present, as in the former, edition, the Author has not hesitated to appropriate whatever was deemed valuable and approved from all the sources at his command, but he has aimed, in every instance where the results of the labors and experience of others have been embodied, to accord the proper credit. For the many personal favors and courtesies generously extended to him by individual members of the profession, his thanks are, in an especial manner, due.

Terre-Haute, Ind., November, 1868.

PREFACE TO FIRST EDITION.

In the preparation of the following treatise, the author has endeavored to present, in as concise and methodical a form as possible, the material facts and principles which relate to the Mechanical Department of Dental Practice in its present advanced condition. In the accomplishment of this undertaking, the primary and leading purpose has been to furnish the student and more inexperienced practitioner with a practical guide to the manipulations of the laboratory, with accompanying elucidations of the elementary principles which underlie the practice of this important specialty. In furtherance of this design, all matters, discussions and commentaries not strictly material, have been carefully excluded.

The arrangement and treatment of the various subjects embraced are such, it is believed, as will best facilitate the student in the acquisition of a knowledge of the department alluded to, and the practitioner in the intelligent and successful conduction of the manipulations which appertain to this branch of Practical Dentistry.

In the belief that these objects have been mainly accomplished, the work is respectfully submitted to the profession.

J. Richardson.

Cincinnati.

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MECHANICAL DENTISTRY.

PART FIRST.

METALS EMPLOYED IN DENTAL LABORATORY OPERATIONS, WITH PRELIMINARY OBSERVATIONS ON THE DIFFERENT MODES OF APPLYING HEAT.

CHAPTER I.

DIFFERENT MODES OF APPLYING HEAT.

THE application of heat to the various mechanical processes of the dental laboratory would seem to require a brief description of some of the agencies employed for the purpose. As full a description of the appliances used will be introduced as is compatible with the scope of the present work.

BLOWPIPE.

Various modifications in the form of the blowpipe have been introduced from time to time, and are named according to the means used to produce the blast, as, *Mouth*, *Bellows*, *Self-acting* or *Spirit*, and *Hydrostatic* Blowpipe.

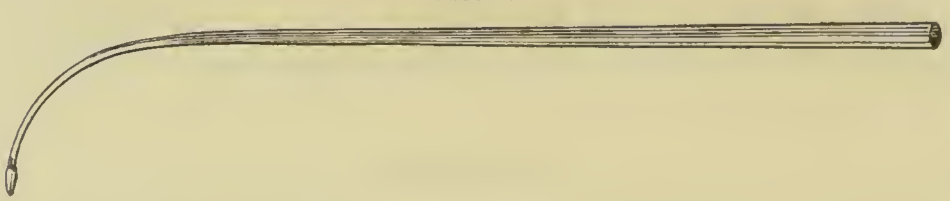
In addition to the varieties mentioned, there are others used in producing extreme degrees of heat, as the "*oxygen blowpipe*" with which the flame is blown with a jet of oxygen; and another, with which the two gases, oxygen and hydrogen,

are burned, called the "*oxy-hydrogen blowpipe.*" The latter is capable of producing a heat that immediately fuses the most refractory substances, as quartz, flint, rock-crystal, plumbago, &c. With it, gold is volatilized, and iron rapidly consumed when placed in the flame; while platinum, next to iridium, the most infusible of all known metals, has been melted in quantities exceeding one hundred ounces by means of this powerful instrument. As, however, these blowpipes are of no special practical utility in the dental laboratory, any further reference to them will be omitted.

Mouth Blowpipe.—This instrument has been long in use, is simple in its form and construction, and, for general use in the application of moderate degrees of heat, is both convenient and economical. Those accustomed to its use are enabled to produce a continuous blast of considerable force, and soon acquire the facility of regulating the heat produced with equal if not greater precision than can be readily attained in the use of either of the other varieties mentioned.

The most simple form of the mouth blowpipe is shown in Fig. 1. It consists usually of a plain tube of brass, larger at the end applied to the mouth, and tapering gradually to a point at its other extremity, the latter being curved and

FIG. 1.

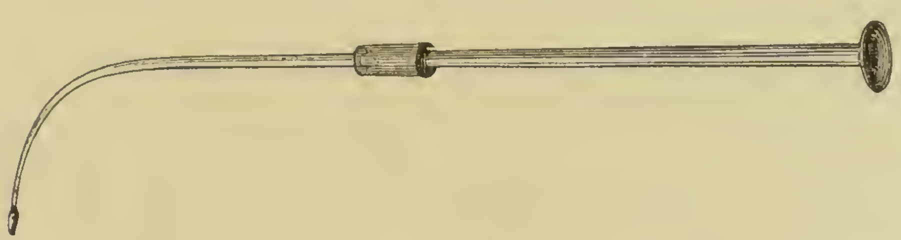


tipped at the point with a conical-shaped, raised margin to protect it from the action of the flame: the calibre of the instrument terminates here in a very small orifice. The point of the instrument, as well as that part of it received into the mouth, is sometimes plated with a less oxydable metal than brass, as silver or platinum. The stem is generally from twelve to twenty inches in length, and the mouth extremity from one-half to three-fourths of an inch in diameter.

In operations requiring protracted blowing, a somewhat different form of the instrument will be required, owing to the accumulation of moisture within the tube, which, being forcibly expelled from the orifice, spirts upon whatever is being heated and interrupts the blast; also, on account of the fatigue which in process of time renders the muscles of the mouth and face engaged in the act to a great extent powerless.

The difficulties mentioned may be obviated, in a great measure, by applying the form of blowpipe represented in Fig. 2. To the mouth extremity is attached a circular concave flange or collar which receives and supports the lips. To the shaft, near its curved extremity, is adjusted either a spherical or

FIG. 2



cylindrical chamber which collects and retains the moisture as it forms within the pipe. By allowing that part of the tube connected with the curved end to pass part way into the chamber, a basin is formed at the depending portion of the latter, which, by collecting the fluids, will effectually prevent them from overflowing and passing into the tube beyond.

There are other modifications of the mouth blowpipe somewhat allied in form to the one last described, but as they are constructed more especially for chemical examinations or analyses, and as they possess no advantages for dental purposes over those already mentioned, a description of them is not deemed necessary.

Mechanism involved in the act of producing a continuous blast with the mouth blowpipe.—As a steady, continuous current of air from the blowpipe is preferable to the interrupted

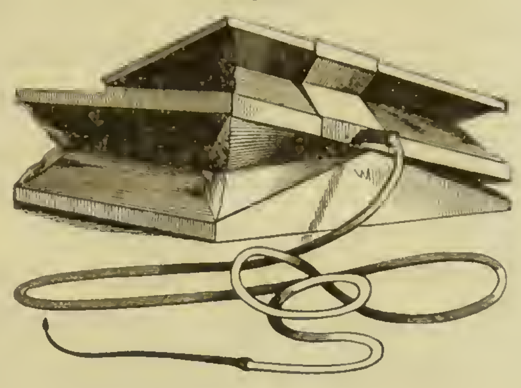
jet, in all those operations where it is desired to produce a steadily augmenting heat, the following remarks, explanatory of the method of producing it, are subjoined in the belief that they will render easier a process not always readily acquired.

"The tongue must be applied to the roof of the mouth, so as to interrupt the communication between the passage of the nostrils and the mouth. The operator now fills his mouth with air, which is to be passed through the pipe by compressing the muscles of the cheeks, while he breathes through the nostrils, and uses the palate as a valve. When the mouth becomes nearly empty, it is replenished by the lungs in an instant, while the tongue is momentarily withdrawn from the roof of the mouth. The stream of air can be continued for a long time without the least fatigue or injury to the lungs. The easier way for the student to accustom himself to the use of the blowpipe, is first to learn to fill the mouth with air, and while the lips are kept firmly closed to breathe freely through the nostrils. Having effected this much, he may introduce the mouth-piece of the blowpipe between his lips. By inflating the cheeks, and breathing through the nostrils, he will soon learn to use the instrument without the least fatigue. The air is forced through the tube against the flame by the action of the muscles of the cheek, while he continues to breathe without interruption through the nostrils. Having become acquainted with this process, it only requires some practice to produce a steady jet of flame. A defect in the nature of the combustible used, as bad oil, such as fish oil, or oil thickened by long standing or by dirt, dirty cotton-wick, or an untrimmed one, or a dirty wick-holder, or a want of steadiness of the hand that holds the blowpipe, will prevent a steady jet of flame. But, frequently, the fault lies in the orifice of the jet, or too small a hole, or its partial stoppage by dirt, which will prevent a steady jet of air and lead to difficulty. With a good blowpipe, the air projects the entire flame, forming a horizontal, blue cone of flame, which con-

verges to a point at about an inch from the wick, with a larger, longer, and more luminous flame enveloping it, and terminating to a point beyond that of the blue flame."*

Bellows Blowpipe.—This form of blowpipe, although superseded in a great degree by other modifications more recently introduced, is well adapted to all the minor operations of the shop, provided it is so constructed as to produce a continuous and equable current of air. A very efficient form of this apparatus, contrived by Drs. McDaniels and Roudebush, is exhibited in Fig. 3. It consists of three distinct chambers; two lower ones, separated from each other in the centre, and one above, communicating by valvular openings with the former. The basement boards of the lower compartments are accurately joined to each other in the centre with an inclination like that of an ordinary roof; are each about six inches square and have apertures in the centre with valves opening upward. The upper borders of these chambers are formed by the treadle or foot-board, consisting of a plain board, equal in length and breadth to both chambers, and adjusted by means of hinges to the basement pieces where they unite in the middle;—strips of India rubber cloth being glued along the joints on either side to prevent the escape of air from one chamber into the other. The upper chamber is formed from a strip of board of equal length and half the breadth of the treadle, the ends and sides being closed, as also the lower apartments, with pieces of leather so arranged as to admit of expansion and closure of the air chambers. The lower chambers communicate with the upper or receiving chamber by means of an aperture in the top of each of the former with valves opening into the receiver.

FIG. 3.



* "The Practical use of the Blowpipe." Anon.

The movable top of the upper chamber should be bound down with compressed spiral wires arranged internally, or by strips of India rubber tacked to the borders of the chamber externally so that when the lid of the latter is forced open by the injection of air from the lower chambers, a steady compression of the contained air will be made, forcing it with a steady and continuous impulse into the rubber tube connected with the receiver; the *force* of the current being regulated by the power exerted in depressing either end of the treadle with the foot.

The *modus operandi* of this blowpipe when in use is briefly as follows: One end of the treadle being forced down, the contained air of the corresponding chamber underneath is urged through the valvular opening above into the receiver, while the air at the same time rushes in through the opening in the bottom of the opposite chamber, filling the latter: the other end of the treadle being pressed down, the air in the chamber below is, in like manner, also thrown into the receiver through the opening on the same side above; thus, by an alternate action of the treadle, the receiving chamber is kept constantly replenished.

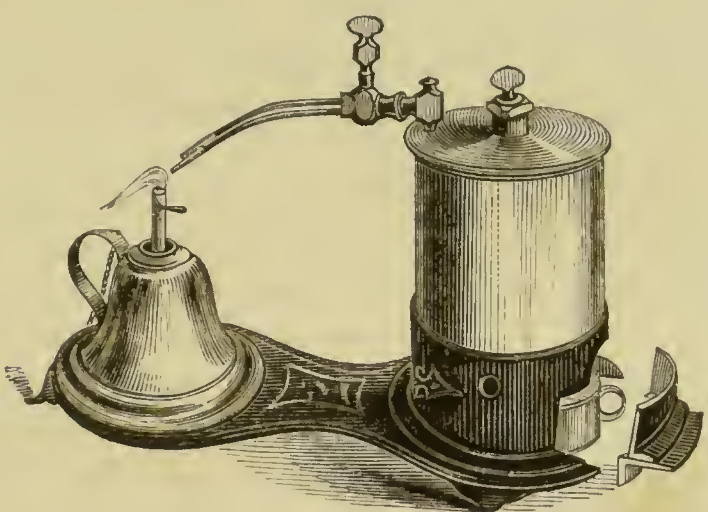
Self-acting or Spirit Blowpipe.—With this instrument the flame is blown with a vapor of boiling alcohol or whiskey. Several varieties have been introduced within the past few years, some of which are well adapted to dental laboratory operations, while others, owing to too great a complexity of mechanism in their construction, by which their action is rendered uncertain and liable to frequent and perplexing interruptions, have not been generally adopted; others, again, are regarded as too unsafe and inconvenient for laboratory uses.

One of the best implements of the kind, simple in its contruction and design, and at the same time safe, convenient and manageable, is what is known as "Hollely's Self-acting or Spirit Blowpipe." A description of this apparatus will serve to convey a sufficiently distinct idea of the *prin-*

ciple involved in the various modifications of the blowpipe under consideration.

The accompanying cut, Fig. 4, exhibits the different parts in their proper relation when in use. It consists of a cylindrical boiler, usually of brass, with a square-capped safety valve on top, so arranged as not to admit of complete closure, thereby rendering an explosion of the boiler impossible. The pressure of the contained vapor, and, by consequence, the

FIG 4.



power of the jet may be increased by turning the thumb-screw connected with the valve forward, and lessened by a reverse movement of the same. The valve fixture may be removed by unscrewing it, and alcohol introduced into the boiler through the opening; the boiler being from one-half to two-thirds full when in use. To the top of the latter near the side two pipes are attached communicating with the interior of the boiler, and which are provided with a gauge-cock, by which the operator is enabled, by a partial rotary movement of a thumb-screw, to control, somewhat, the force of the vapor current through the pipes, and also to transfer the jet from one pipe to the other, as he may desire a pointed or spreading flame; or a commingling jet from both pipes may be simultaneously produced whenever a very large and diverging flame is required.

A small alcohol lamp being lighted, is placed underneath the boiler, when, after the lapse of a few minutes, a current of vapor will be forcibly expelled from the orifices of the pipes, and may be directed against the flame of any of the lamps in common use for heating purposes.

A blowpipe like the foregoing will be found serviceable in all operations requiring a protracted blast, and, in common with the bellows and hydrostatic blowpipes, will be found of especial service to those whose eyes and lungs are injuriously affected, as they sometimes are, by the use of the mouth blowpipe. It is also portable, as the various parts of which it is composed may be readily detached and packed within a small space.

Hydrostatic Blowpipe.—This blowpipe is of comparatively modern origin, and for many purposes in the dental laboratory is the best that has yet been introduced. With it, a constant, equable, and forcible current of air may be produced and maintained for a length of time equal to the capacity of the water-chamber; and for all operations requiring a high and steady heat it is invaluable.

Fig. 5.

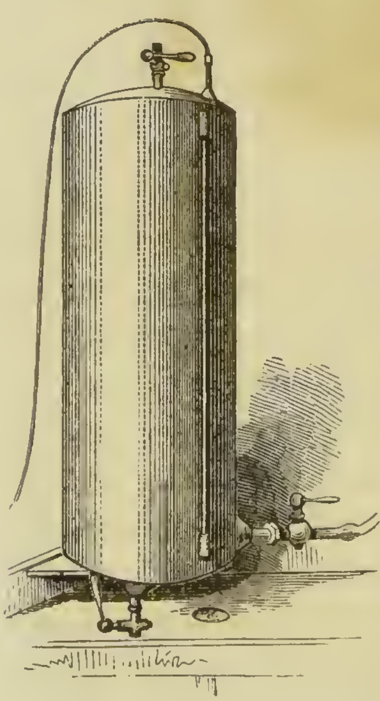


Fig. 5 represents an apparatus of this kind, which is so simple and economical in its construction, that every dentist may, with little trouble and at a trifling cost, provide one for his laboratory.

By reference to the annexed illustration, it will be seen to consist of a tank or cylinder made of sheet-iron, zinc or copper, of variable dimensions, usually, however, from four to six feet in length and from twelve to twenty inches in diameter. To the side of the

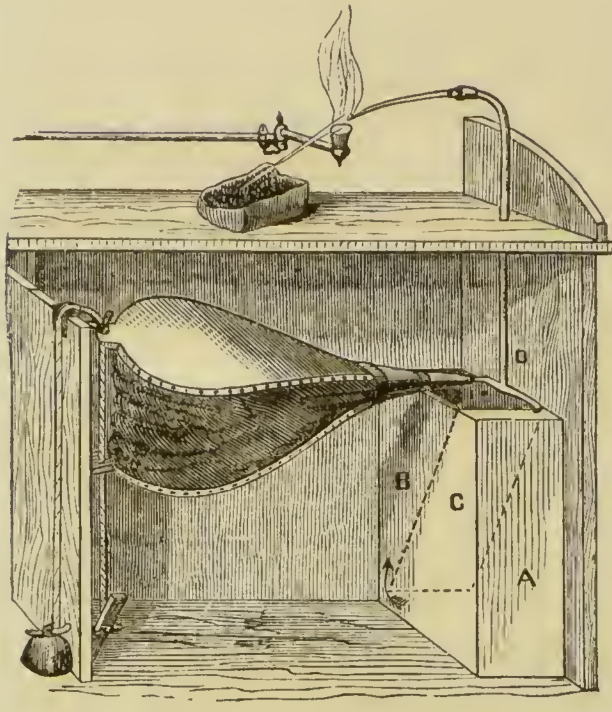
cylinder near the bottom a pipe with faucet is attached, called the "supply pipe," and is designed to convey water to the tank; another is attached to the bottom, termed the "waste pipe," and is used to discharge the contained water. To the centre of the top of the cylinder is adjusted a stop-cock to freely admit the ingress of air when the water is being discharged, without which the sides of the cylinder would tend to collapse on the formation of a vacuum within. An India rubber tube is also united to the top of the cylinder on one side, and is attached at its other end either to an ordinary mouth blowpipe or gas jet.

The water being admitted to the tank through the supply pipe, the contained air is compressed and forcibly expelled through the air-tube and orifice of the blowpipe upon the flame; the force of the jet being regulated by the stop-cock connected with the supply-pipe. When the cylinder becomes filled, or partially so, the faucet on the top should be opened and the water drawn off through the discharging pipe. A small glass tube, communicating with the interior of the cylinder on one side near the bottom, extending up the side, and again entering the cylinder at the top, will be found useful as a guide to determine, at any time, the depth of water in the tank, the water in the tube maintaining the same level with that in the former.

Those unable to command the facilities afforded by water power, may avail themselves of the following contrivance which combines mainly all the advantages of the blowpipe just described. A cylinder of the form mentioned, but with an open top, is partially filled with water, and another, similiarly formed but inverted, or with its closed end above, is made to fit and slide into the first. Weights are then placed on the top of the inverted tank, when the air within the latter will be forcibly compressed and impelled, as in the other case, through an air-tube attached to its upper closed extremity.

The following description of a hydrostatic blowpipe, (Fig. 6,)* of simple but ingenious construction is given by Prof. C. A. Kingsbury, in the March (1864) No. of the Dental Cosmos, and which he affirms, after extended experience in its use, is "one of the most simple and effective I have ever seen where a stationary blow pipe is needed for the dental laboratory."

Fig. 6.



"A, represents a front view of a zinc or copper tank 20 inches high, 15 inches long, and 8 inches wide. B represents a side view; and the dotted line between B and C a partition passing from within about an inch of the front upper angle down to within an inch of the lower back angle of the tank: or, in other words, this partition runs diagonally from the front upper angle to the lower back angle. This partition must be water tight, except at the bottom of the tank, where an open space is left of about an inch, so that when water is poured into the open compartment B—which is nearly as wide at the top as the tank is long—it can readily flow into the compartment C. When the tank is filled nearly half full it will be seen that the great bulk of the water will be in the front compartment C. The bellows is an ordinary large size house-bellows. The end of it rests upon the top of the

* The accompanying illustration was kindly furnished, at the instance of Prof. K., by Dr. S. S. White, for which and other similar favors the author would express his grateful acknowledgments.

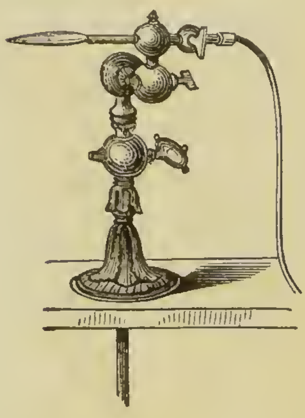
tank, and the handle of the bottom part is made fast to an upright strip of board. A cord connected with the upper handle, having a weight of four or six pounds attached to the other end, passes over a small pulley for the purpose of raising the bellows. A cord connected with the same handle is attached to a small foot-lever or treadle, and by this means the bellows is easily worked with the left foot. To the nozzle of the bellows there is fastened one end of a plumber's small brass joint; the other end of the joint is soldered to a piece of small-sized lead pipe which communicates with the compartment C at the top. In this brass joint is placed a leather valve—which any dentist of ordinary ingenuity can construct for himself—to prevent the air from returning back into the bellows. Connected with the lead pipe, running from the nozzle to the compartment C, is another piece (D), passing up through the work-bench or table, as the case may be, to which an old fashioned brass mouth blow-pipe is soldered. When the bellows is moved, the air is forced out of the pipe D and also into the compartment C, which becomes a reservoir for the air. For as the air presses down upon the surface of the water in C it is forced in the direction indicated by the arrow into the compartment B, which is open at the top. As the water is forced by the air in C into B its weight acts upon the air in C to drive it out of the pipe D, and in this way a steady and continuous blast, capable of being graduated to the wish of the operator by the greater or smaller quantity of water acting upon it, may be maintained with the most perfect ease. Any tinman can make the tank and its connections. Tin or zinc will do, but in the long run tinned copper would be the most economical. The apparatus should be placed at one end of the bench, or in some convenient place where it will not occupy much room.

"It will be observed that in using this blow-pipe both hands are free to handle the piece of work, and the lungs and mouth are also free to perform their natural functions.

I am sure any one using this blow-pipe for one month could never be prevailed upon to abandon it. . . . . The intensity of the flame is such as to enable me to melt an ounce of gold in a few minutes; and it will be found sufficient for all the practical requirements of a dentist's blow-pipe. With the ordinary movable gauze gas burner for soldering, the size of the flame can be graduated by a slight change in the position of the burner, as may be desired."

The oil or alcohol lamp in common use will serve for either of these blow-pipes, but a gas-jet, whenever it can be conveniently commanded, is preferable to either. Fig. 7 represents an improved apparatus employed in the application of the air-jet to the gas flame.

Fig. 7.



A movable gas-jet, attached to two short arms of an ordinary gas-pipe, is made to receive within it the blow-pipe point connected with the rubber tube, the air-tube, terminating a little within the open mouth of the gas jet; it is thus a tube within a tube, with a space between them for the admission and passage of gas. The gas being admitted by turning the screw connected with the gas-pipe, is ignited, and the current of air admitted from the rubber tube by turning a similar screw attached to the air-pipe, when the jet of air will strike the centre of the flame and project it upon the substance to be heated. The connected portions of the air and gas jets are so attached to the main pipe as to admit of an upward and downward motion, while the volume of gas and air is readily graduated by the stop-cocks attached to the former.

This arrangement is one of the most complete and efficient for blowpipe purposes that has yet been devised. The jet may be elevated or depressed at will, while the force of the air-current and the volume of gas-flame can as readily be increased or diminished. The operator is thus enabled, with

the greatest ease, to produce a heat adapted to the most delicate operations, or to instantly change it to a heat so intense that pure gold in considerable quantities is almost immediately fused in the flame. It is, therefore, well adapted to all operations in the laboratory, but will be found of especial utility in the construction of work requiring pure gold as a solder.

LAMPS.

The lamps most commonly used by dentists in blowpipe manipulations are oil and spirit lamps.

Oil Lamp.—When oil is burned, the form of lamp represented in Fig. 8 may be used. It should hold from one to two pints, and should have a spout one inch or more where it joins the body of the lamp, tapering gradually to three-fourths of an inch at the top. The spout should be well filled with wick, but not so tightly as to prevent it from being freely saturated. The best combustible is pure sweet oil, but common lamp or lard oil is generally employed and answers every practical purpose. The wick should be kept well cleaned and trimmed, and fresh oil should be substituted whenever that in use becomes thickened by dirt or otherwise deteriorated.

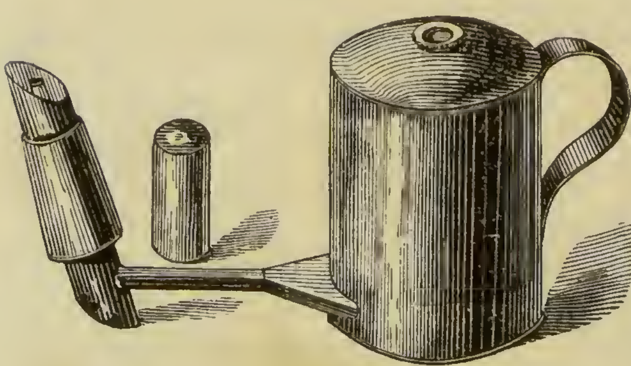
Fig. 8.

Spirit Lamp.—Alcohol is preferred by many on account of its greater cleanliness, although it does not afford so great a heat as oil. When spirit is employed a somewhat different form of lamp should be used. With one like that described for oil, there is danger of explosion in the event of the flame, mixed with air, communicating with the alcohol contained in the lamp, and which is more liable to happen when the spout

is but loosely filled with wick. To provide against such casualty, it is not unusual to pack the wick too closely, which, by obstructing the flow of alcohol into the spout, lessens the heat of the flame. The proximity of the flame, also, to the body of the lamp, produces undue waste of alcohol by evaporation.

The objections stated may be obviated by employing a lamp of the form shown in Fig. 9. With a lamp like that represented, the spirit is entirely uninfluenced by the heat of the flame, while explosion is rendered impossible. The centre of the upright portion of the spout is traversed by a small tube extending throughout, and open at both ends to admit of the application of a jet of air to the lower orifice, impelling the flame from the centre and thereby intensifying the heat. Around this central tube the wick is arranged; the space occupied by the latter communicating with the body of the lamp through the horizontal arm of the spout.

Fig. 9.



FURNACES.

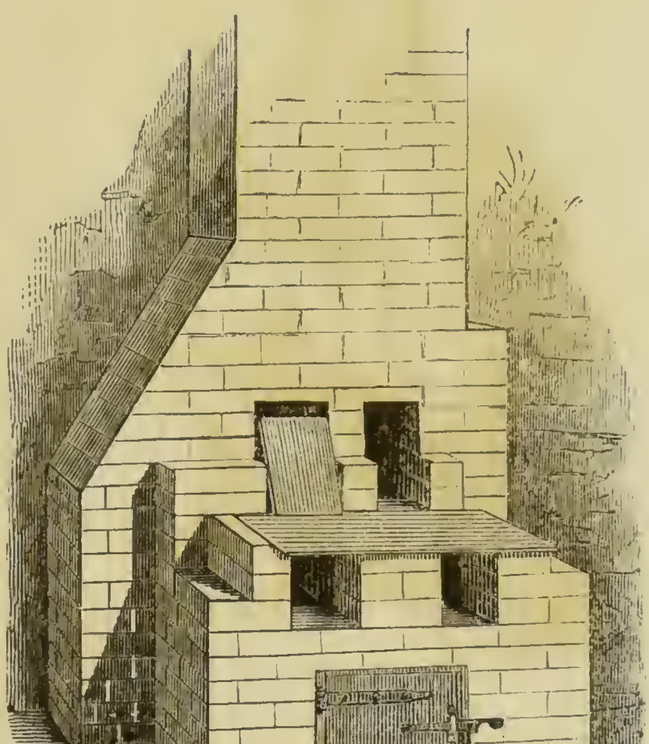
It would be inconsistent with the design of the present work to introduce a description of any forms of furnace other than those commonly used by the dentist. Those used in the arts, or for chemical and pharmaceutical purposes, embrace almost endless varieties, and have no special adaptation to the uses required of them in the dental laboratory.

Draught or Wind Furnace.—A very convenient, portable and economical furnace may be made of sheet-iron, of any

desired shape or dimensions, though usually of small size, and cylindrical in form. A light grate, or heavy piece of sheet-iron perforated with holes to admit of the passage of air, should be adjusted near the bottom, while above and below the grate are two openings, the lower one communicating with the ash-pit, and the upper one for the introduction of fuel and substances to be heated. By surmounting this simple apparatus with a pipe, or connecting it with the flue of a chimney, it will be found efficient in many of the minor operations of the shop, as melting metals, heating pieces preparatory to soldering, annealing, &c.

A more durable and serviceable draught furnace, however, may be built of masonry, a convenient form of which is represented in Fig. 10. The construction of this stationary fixture is so plainly exhibited in the cut that any extended description of it is deemed unnecessary. The upper holes represent the entrance to the fire-chambers which are distinct from each other; the lower ones communicate with the ash-pit which is common to both chambers. Two fire apartments are here shown; one for melting and refining the more precious metals, heating up operations for soldering, &c.; the

Fig. 10.

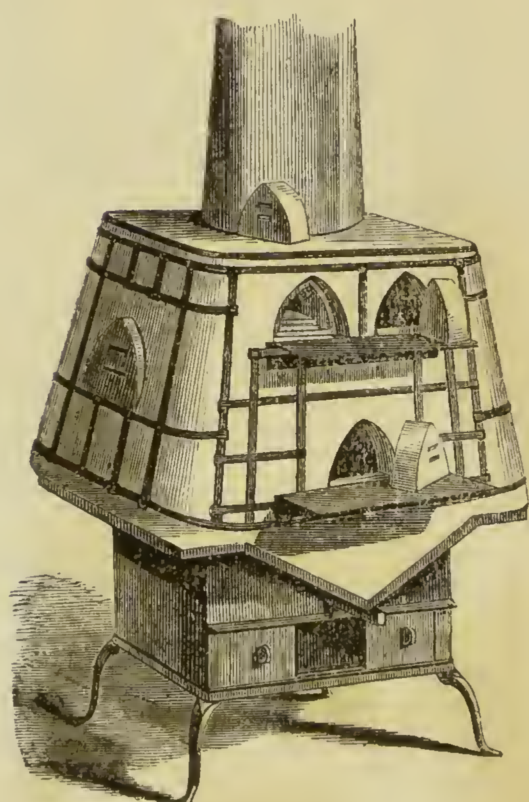


other being used exclusively for fusing the baser metals, as zinc, antimony, lead, &c. These furnaces are sometimes constructed with a single fire-chamber, but the one exhibited is, in every way, preferable.

Baking Furnace.—The chief purposes to which these furnaces are applied are the manufacture of porcelain teeth, single and in sectional blocks, the preparation of silicious compounds, and the construction of what is known as "continuous gum-work." The most recent and approved form of this furnace is exhibited in Fig. 11.

The body of the furnace rests upon a cast-iron frame-work or basement, which serves the purpose of an ash-pit. The grate immediately over this inclines from each side of the furnace toward the bottom and the centre of the ash-pit, to afford more ample room for fuel directly underneath the lower muffle. The upper portion or body of the furnace is made of fire-clay, and contains three muffles arranged horizontally; the upper two, termed "annealing muffles," are designed, more especially, for drying substances, partial heating preparatory to final baking, and to receive substances from the lower muffle to be gradually cooled. The lower or main muffle is for general baking purposes requiring the employment of extreme degrees of heat. Each muffle is provided with fire-clay slabs or slides, on which substances to be heated are placed and

Fig. 11.



introduced into the muffles; and also plugs of the same material to close the openings to the former. Openings are made on each side of the furnace, intermediate between the muffles, for the introduction of fuel, and to afford ready access to the latter with tongs or other implements. These entrances are also provided with plugs which are applied during the process of heating. This furnace should be connected with a flue having a strong and unobstructed draught.

FUEL.

Under this head are comprehended such combustible substances as are used for fires or furnaces, as *wood*, *coal*, *charcoal*, and *coke*. For dental furnace operations, only the latter two are, as a general thing, admissible.

Bituminous, or *pit-coal*, is unfit for the uses required of fuel by the dentist, and is, therefore, seldom used.

Anthracite coal, if carefully selected, may be employed, provided it is clean, free from slate, and does not yield a fusible ash. As charcoal and coke are the fuels chiefly used in the processes of the laboratory, these substances will be more particularly described.

Charcoal.—Charcoal is obtained by igniting wood and then excluding it from the air while burning; the volatile products are thus driven off while the carbon remains. When combustion has proceeded slowly for a certain length of time, the openings to the bed or mound are closed, and the wood allowed to char.

When it is desired to maintain a high heat in a small compass, the charcoal best adapted to the purpose is that obtained from what is termed *hard* wood, as the beech, the oak, the alder, the birch, the elm, etc. A cubic foot of charcoal derived from these woods weighs, upon an average, from twelve to thirteen pounds; while a similar bulk obtained from *soft* wood, as the fir, the different kinds of pine, the larch, the linden, the willow, and the poplar, averages only from eight

to nine pounds.* There is, therefore, economy in the use of the former when purchased by the bulk; and of this class the beech-wood charcoal is the best, on account of its greater specific gravity. The more heavy charcoals require a stronger draught than those of a lighter character, as a more generous supply of oxygen is necessary to their perfect combustion. Charcoal should be kept as dry as practicable, since it rapidly absorbs moisture from the atmosphere, by which its calorific energy is materially impaired.

Coke.—This substance, like charcoal, is a carbonaceous residuum obtained from pit-coal that has been exposed to ignition for some time excluded from the contact of air, the volatile products of the coal, like those of wood, having been driven off by the heat. Coke differs in appearance as well as in quality. The principal part of that obtained from gas-houses is of a dull, iron-black color, very spongy and friable, and is more rapidly consumed, and produces less heat than the harder and more compact kinds. The best coke for furnace use is that used by brassfounders, and has a steel-gray color with a somewhat metallic lustre; is compact in its structure, and splits into pieces having a longitudinal fracture.

Coke does not readily ignite, and, at first, generally requires the admixture of charcoal to effect its combustion; it also requires a strong draught to burn it, but when thoroughly ignited, it produces an intense and persistent heat. It is the principal fuel used in baking mineral teeth, porcelain blocks, and the silicious compounds employed in the fabrication of continuous gum work.

Professor Piggot, in his remarks on the comparative value of fuels, observes: "Practically, for the purposes of the chemist, the best fuel is charcoal or coke, or a mixture of the two. The ash of charcoal being infusible, it passes through the bars of the grate as a white powder. Should potash, how-

* Ure.

ever, be in large excess, it corrodes the bricks, by forming with them a silicate of potash, which runs down the walls and chokes the bars. In small quantities, this action is beneficial, as it furnishes a protective varnish, and unites the bricks and lutes, by forming a sort of cement, which intimately combines with them.

"Coke contains a very variable amount of ash, which is composed chiefly of oxide of iron and clay. The latter is not fusible by itself, but may soften. When pure, it forms a harmless slag, which injures neither the furnace nor the crucibles. Usually, however, the oxide of iron predominates. In this case the ash is very injurious, for it is reduced to a protoxide, which is not only fusible, but powerfully corrosive to all argillaceous matters, so that both the crucibles and furnaces suffer."*

In order that the greatest amount of heat may be evolved from these fuels, it is necessary that the conditions necessary to secure their perfect ignition should be strictly observed; these have reference to an unobstructed circulation of air that oxygen may be freely supplied to them. To this end the furnace should be kept clean, the bars of the grate unbroken, and a good draught obtained. The condition in which the fuel is applied will also modify the results: thus, for example, if the lumps are too large they will absorb heat, and caloric will be lost; if too small, they will be too rapidly consumed. It is essential, also, to have the fuel as free as possible from dust and dirt, as these fine particles, in any considerable quantities, obstruct the draught and prevent a thorough ignition of the mass. Coke, especially, should be preserved clean, and should be broken into fragments not larger than an inch or an inch and a half in diameter, and, as nearly as possible, in the form of blocks or cubes, as these leave more open spaces for the free circulation of the air.

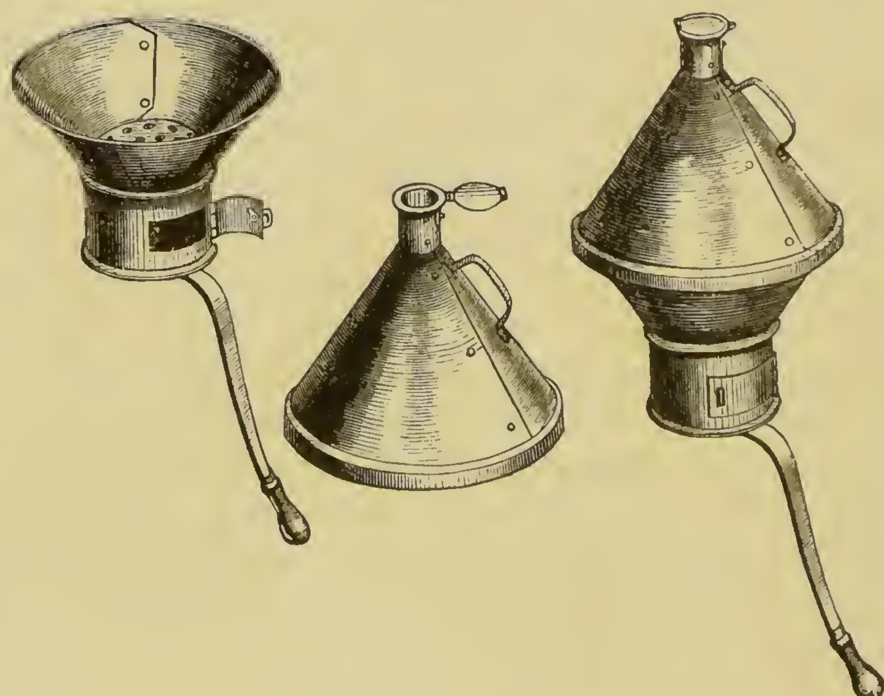
* Dental Chemistry and Metallurgy, p. 274.

SUPPORTS.

There are many processes in the dental laboratory requiring the application of heat, for which a suitable holder or support should be provided. A very convenient form of holder used in soldering may be made of a circular or semi-eliptical piece of heavy sheet-iron, the margin being serrated and turned at right-angles, forming a cup. To the under side and centre of this, an iron rod, ten or twelve inches long, may be permanently riveted; or it may be made to revolve on the handle, so that the heat may be thrown directly upon any particular part of the piece to be soldered without disturbing the latter.

A small *hand-furnace* (Fig. 12) is sometimes used, and will be found a very convenient and useful apparatus, not only for

Fig. 12.



soldering, but for preparatory heating. It consists of a funnel-shaped receptacle made of sheet-iron, with a light grate or perforated plate of the same material adjusted near the bottom, and an opening on one side, underneath the grate, for the admission of air. The upper part of the holder is

surmounted by a cone-shaped top, which may be readily removed by a handle attached to it; while to the bottom of the furnace is attached an iron rod five or six inches long, and terminating in a wooden handle. The piece to be soldered is to be placed inside on a bed of charcoal, the top adjusted to its place, and the fuel ignited; when the operation is sufficiently heated, the top may be lifted off, and the piece, remaining in the furnace, soldered with the blowpipe in the usual manner, the furnace thus serving the purpose of a holder.

A support in very common use consists simply of a large, close-grained piece of charcoal, invested in plaster one-half or three-fourths of an inch thick, one end or side being left open and scooped out to receive whatever is being heated. Or a plaster cup two or three inches deep may be made, and its interior partly filled with a mixture of plaster, sand, asbestos, and pulverized charcoal.

CRUCIBLES.

Crucibles are small conical-shaped vessels used by the dentist principally for the purposes of melting and refining metals used for plates, compounding metallic alloys, preparing and compounding the various ingredients employed in the manufacture of porcelain teeth and continuous gum work, etc. They combine in a high degree the properties of infusibility, exemption from the attack of substances fused in them, the power of resisting sudden alternations of temperature, and impermeability to fluids and gases. The Hessian crucibles, which are in most common use among dentists, are composed of silica, alumina, and oxyd of iron. For a more particular description of the various components entering into the structure of crucibles, as well as the manner of manufacturing them, the reader is referred to Piggot's "Dental Chemistry and Metallurgy," and other works treating more fully of the subject.

CHAPTER II.

GOLD.

Gold has been known from a period of great antiquity, having, according to the writings of Moses, been wrought into articles of jewelry more than three thousand years ago. As a base or support for artificial dentures, it has entirely superseded the use of the various animal substances formerly employed, and, by the mass of practitioners at the present time, it continues to be the most highly esteemed metal for the purpose mentioned, notwithstanding the more recent introduction of approved processes in which, as a base, this metal is wholly discarded.

Gold is found only in the metallic state, and occurs either crystallized in the cube, and its allied forms, or in threads of various sizes, twisted and interlaced into a chain of minute octahedral crystals; also in spangles or roundish grains. These latter, when they occur of a certain magnitude, are called *pepitas*, some specimens of which have been obtained of great size. In 1810 a mass of alluvial gold weighing twenty-eight pounds was found in the gravel pits of the creeks of Rockhole, in North Carolina. A lump of gold ore weighing three cwt., was forwarded from Chili, South America, as a contribution to the World's Exhibition in London. New Granada, California, Russia, and Australia, have each produced pepitas or masses of gold weighing respectively twenty-seven and a half, twenty-eight, seventy, and one hundred and six pounds.

Geological Situations.—The crystalline primitive rocks, the compact transition rocks, the trachytic and trap rocks, and alluvial grounds, are the formations in which gold occurs.

Unlike many other metals, it is never in such large quantities as to constitute veins by itself, but is either disseminated through the rocky masses, or spread out in thin plates or grains on their surface, or confined in their cavities in the shape of filaments or crystallized twigs. The minerals composing the veins are either quartz, calcspar, or sulphate of baryta. The ores associated with the gold in these veins are principally iron, copper, arsenical pyrites, galena, and blende. The most abundant sources of gold, however, are in alluvial grounds, where it is found distributed in the form of spangles in the sands of certain plains and rivers, especially at their re-entering angles, at the season of low water, and after storms and temporary floods. Sufficient reasons have been advanced in support of the belief that gold, found in alluvial situations, belongs to the grounds traversed by these rivers, instead of being washed, as was formerly supposed, from the mountains in which their waters have their origin.

Geographical Distributions.—The European mines, more particularly distinguished for their richness, are in Hungary and Transylvania, especially the former. Gold also occurs, but more sparingly, in Ireland, Sweden, Siberia, Germany, Russia, and Spain. In *Asia* and *Africa*, the mines which yield most abundantly, are situated in the southern portions of these continents. From the latter, the ancients derived the greater portion of their gold. Several of the *South American* provinces yield this metal in considerable quantities. Washings are also common in several States of the Union, but California stands unrivaled, except by Australia, in the immense productiveness of its mines, and its resources in respect to this rare and valuable metal are reckoned inexhaustible.

Properties of Gold.—Pure gold is distinguished from all other metals by its brilliant orange-red or yellow color, being the only simple metal that possesses this complexion. It is susceptible of a high polish, but is inferior in brilliancy to steel, silver or mercury. Its specific gravity varies some-

what, according as it is fused or hammered; the former having a density of 19·26; the latter ranging from 19·4 to 19·65. It is only excelled in density, therefore, by platinum, the specific gravity of which is 21·25.

Gold surpasses all other metals in malleability. The average thickness of ordinary gold leaf is $\frac{1}{282000}$ of an inch, but the ultimate degree of attenuation of which pure gold is susceptible exceeds considerably this estimate. It is also distinguished for its ductility. A single grain of gold may be drawn into wire 500 feet in length, while an ounce may be made to extend 1,300 miles. It is somewhat softer than silver, and possesses great tenacity, though inferior in this quality to iron, copper, platinum or silver. A thread of gold $\frac{78}{1000}$ of an inch in diameter will sustain a weight of 150 pounds. Gold fuses at 2016° with considerable expansion, and, on cooling, contracts more than any other metal.

On account of the want of affinity of gold for oxygen, it remains unaltered in the longest exposure; it is incapable of being oxydized in any heat that may be applied to it, and is only volatilized with great difficulty in the resistless heat of the oxy-hydrogen blowpipe. It is unaffected by the most concentrated of the simple acids, but is readily soluble in *aqua regia* or nitro-muriatic acid, and nitrofluoric acid.

It will thus be seen that gold possesses, in an eminent degree, those general properties which render it peculiarly fit for the purposes to which it is applied in the practice of dental prosthesis.

Influence of Alloying on the Properties of Gold.—The term *alloy* signifies a compound of any two or more metals, as brass, which is an alloy of copper and zinc.

Alloys, in respects to their uses, are practically new metals, and differ in many important respects, both in their chemical and physical characteristics, from the constituent metals of which they are composed. A more particular account of the influence of alloying upon the general properties of metals, and their management and behavior in the process of com-

pounding, will be given under the head of alloys of the baser metals. As gold combines readily with most metals, some of the more prominent conditions which distinguish its alloys will be given.

The *malleability* of gold is, strictly speaking, always impaired by its union with other metals. This effect is eminently characteristic of certain contaminations, as those with arsenic, tin, antimony, bismuth, lead, &c.; while with certain other metals, as silver, copper and platinum, unless in excess, this property of gold is so little affected, as in no material degree to interfere with its being worked into any desired form for dental purposes. The *ductility* of gold is also usually diminished by its incorporation with foreign metals; sometimes in a remarkable degree. Gold is always rendered *harder*, and its *tenacity* is generally increased, by alloying, while its *density* varies with the particular metal or metals with which it is combined. Thus, the alloy of gold with either zinc, tin, bismuth, antimony or cobalt, has a density greater than that of the mean of its constituents, while the alloys of gold having a less specific gravity than the mean of their components are those with silver, iron, lead, copper, iridium or nickel. Gold is ordinarily more *fusible* when alloyed, the alloy always melting at a less heat than that required to fuse the most refractory constituent, and oftentimes less than the more fusible component. The alloy of gold and platinum furnishes an example of the former; the platinum, which in its uncombined state is infusible in the highest heat of a blast furnace, forming a fusible compound with gold, the melting point of which is far below that of platinum. Gold solder, composed of gold, copper and silver, affords a familiar illustration of the latter; the alloy melting at a less heat than that required to fuse its least refractory component, silver. Gold, which in its pure state has less affinity for oxygen than any other metal, is rendered more or less oxydable when combined with other metals.

That gold alloys tend to be formed in definite proportions

of their constituents would appear from the phenomenon observed in the native gold of the auriferous sands, which is an alloy with silver in the ratio of 1 atom of silver, united to 4, 5, 6, 12 atoms of gold, but never with a fractional part of an atom. The same circumstance is noticed in connection with the amalgam of silver and mercury. But as alloys are generally soluble in each other, the definiteness of this atomic combination is obscured and disappears in most cases.

Properties of Particular Alloys of Gold.—The metals with which gold is liable to become contaminated in the dental laboratory are zinc, tin, lead, antimony, bismuth, iron or steel, mercury and arsenic; as also excess of silver, copper and platinum. As several of these metals when alloyed with gold, even in very minute quantities, are highly destructive in their influence upon those properties which adapt this metal to the various wants of the mechanical operator, and as their separation is often attended with considerable difficulty, annoyance, and loss of time, it is practically important that care should be taken to prevent, as far as practicable, the admixture of any one or more of them with the gold scrap, filings or sweepings, which are to be re-converted into proper forms for use. The accidental intrusion of these metals, however, is, to some extent, unavoidable, and as an acquaintance with the more prominent characteristics or sensible properties of the resulting alloys sometimes furnishes valuable indications in the selection of the proper re-agents employed in their purification, a description of individual alloys is introduced.

Tin, *antimony*, *bismuth*, *lead* and *arsenic* are peculiarly prominent in their effects upon the malleability of gold; either of these metals in exceedingly minute quantities rendering gold intractable.

One part of *antimony* with nine of gold, forms a pale, brittle alloy, and in the proportion of one part of the former

to 1920 of gold, the resulting compound is too brittle to admit of successful lamination.

An alloy of *arsenic* with gold containing $\frac{1}{240}$ of the former is a gray brittle metal, while in the proportion of $\frac{1}{900}$, the malleability of the gold is seriously impaired without suffering any change of color. So energetic is the influence of this metal on gold that the latter is rendered brittle when subjected even to the vapor of arsenic.

Tin, lead and *bismuth* are somewhat analogous to arsenic in their influence upon the malleability of gold, either of them, in almost inappreciable quantities, rendering the latter metal unmanageable under the rollers. One part of lead or bismuth to 1920 of gold converts the latter into an unmalleable metal, while tin exceeds either in its remarkable tendency to render gold hard and brittle. Alloys of gold with tin are of a light color; those with lead are of a darker complexion.

Zinc with gold forms a brittle alloy, and when combined in equal proportions, is exceedingly hard, white, and brittle. Uniting or incorporating itself less intimately with the gold than either lead or tin, however, it not unfrequently happens that portions of the ingot will be brittle while others remain, in some degree, malleable; so that the bar, when rolled out in the form of plate, will be perforated or cracked at those points where the zinc preponderates, while remaining portions of the plate retain a moderate degree of softness and pliability.

The working properties of gold are not sensibly affected by the incorporation of very small quantities of *iron*, as an alloy of these metals, in the proportion of one part of the latter to eleven of gold, remains malleable.

Platinum, in itself a highly refractory metal, is, as before stated, rendered fusible in combination with other metals. When combined with gold in small proportions, the latter is rendered harder and more elastic without having its malleability practically impaired. Platinum very readily affects

the color of gold, the smallest quantities rendering the alloy pale and dull-colored.

Silver unites with gold in every proportion, and is the chief metal employed in the reduction of gold to the required forms for dental uses. It renders gold more fusible, and imparts to it increased hardness without materially affecting its malleability. The alloy is light-colored in proportion to the amount of silver introduced.

Copper, like silver, is usually combined with gold in the formation of plate, solders, etc., and hardens and renders gold tougher without practically impairing its malleability. It imparts to the alloy a deeper red color, and in the form of plate is capable of receiving a polish excelling in richness and brilliancy any other metal.

The foregoing alloys of gold, it will be perceived, are such as result from the incorporation with gold of minute proportions of any one of the base metals mentioned, and possess certain physical characteristics that indicate, with tolerable certainty, the particular alloying component. Thus, for example, if the alloy is light-colored and very brittle, the presence of tin may be suspected; if brittle and dull-colored, lead is indicated; if grayish or dull-colored, but still malleable, tough and elastic, platinum is probably present; if unequally malleable, or brittle in spots, the presence of zinc may be inferred.

Alloys of gold, however, embracing several or all of these metals in varying proportions, are sometimes accidentally formed, in which case the more distinctive features which characterize the binary compounds are lost or obscured.

CHAPTER III.

REFINING GOLD.

Elements Employed.—The separation of foreign metals from gold by what is termed the "dry method," or *roasting*, is effected by the action on them of either oxygen, chlorine, or sulphur, converting them into oxyds, chlorides, or sulphurets. Certain compound substances are used for this purpose which, when heated and decomposed, yield these elements in sufficient quantities for the purposes specified. The refining agents in common use are *nitrate of potassa*, (nitre, or saltpetre,) which yields oxygen; *chloride of mercury* (corrosive sublimate,) which yields chlorine; and *sulphuret of antimony*, (crude antimony,) which yields sulphur. Other compounds contain these elements, but those mentioned are generally preferred, because they contain them abundantly, are readily decomposed by heat, and do not materially interfere with the process of separation by the introduction of troublesome components into the alloy.

Before considering specifically the different modes of refining alloys of gold, it will be convenient to classify the different forms of gold as they occur in working this metal in the laboratory.

1. Plate-scrap or clippings, and plate-filings. These, if proper care is taken to prevent the introduction of fragments of platinum, impure filings, or particles of base metals, only require, provided they were originally of suitable fineness, to be re-melted and again converted into plate or other forms for use.

2. Mixed filings, and fragments containing solder, platinum, etc. These, when melted alone, produce an alloy more

or less impoverished in proportion to the quantity and quality of the foreign metals introduced in finishing pieces constructed of gold, and should be either separately refined by roasting, or reduced to pure gold by the "humid method," to be described hereafter.

3. Sweepings. This form embraces many impurities, earthy and metallic, and should first be thoroughly washed to remove the earthy constituents, after which the remaining metals may either be mixed with class second, or separately refined. Another, and perhaps better, method, is to fuse together the sweepings and substances hereinafter mentioned, in the following proportions: of sweepings, eight parts; chloride of sodium, four parts; impure carbonate of potassa, four parts; impure supertartrate of potassa, one part; and nitrate potassa, half part. Mix them thoroughly together, and melt in a crucible. The crucible with its contents should remain in the fire for some time, in order to secure a complete separation of the metals from extraneous matter.

It is evident from the above classification that much time and labor may be saved by preserving these forms of gold separately as they accumulate in the shop. Separate lap-skins or receptacles, therefore, should be appropriated to the working of gold, one to receive scrap and unmixed plate-filings which may be reconverted into plate without refining; another to collect the solder-filings, and such impure fragments as require purification.

Separation of Foreign Metals from Gold.—The most troublesome ingredients which find their way into gold alloys are what are commonly called *base* metals, as tin, lead, zinc, iron, antimony, bismuth, etc. In attempting to separate these metals from gold, it is not a matter of indifference what re-agent is employed, inasmuch as distinct affinities exist, which may be advantageously consulted. If, for example, zinc or iron, or both of these metals are present in small quantities, any compound which yields oxygen will, by virtue of the affinity of the latter for these metals, effect their

separation by converting them into oxyds; hence, when these metals are to be got rid of, nitrate of potassa is employed. But oxygen has but a feeble affinity for tin, and when this metal is present, its separation is better effected by some compound which parts with chlorine in the act of decomposition; chloride of mercury is therefore used for the purpose. When the alloy of gold contains a number of these metals at the same time, and is very coarse, sulphuret of antimony, which is a powerful and efficient re-agent, should be resorted to, unless the operator should prefer, and which is the better way, to reduce the alloy to pure gold by the "humid method."

After all traces of iron or steel have been removed from the gold fragments and filings by passing a magnet repeatedly through them, the latter should be placed in a clean crucible, lined on the inside with borax, and covered either with a piece of fire-clay slab, or broken crucible. Sheet-iron has been recommended for the latter purpose, but should never be used, as, when highly heated, scales form on the surface, and are liable to drop in upon the fused metals. If the operation of roasting is likely to be protracted, an inverted crucible, with a hole in the bottom, may be securely luted to the top of the one containing the metals; the refining agents and fluxes being introduced through the opening in the upper crucible. These are then placed in the furnace on a bed of charcoal, or what is better, a mixture of charcoal and coke; the latter being built up around the crucible, and over it when covered with a second crucible; care being taken that no fragments of fuel are permitted to fall in upon the fused metals. Small portions of borax may first be added, and when the metals are fluid, the refining agents may be introduced in small quantities from time to time, and the roasting continued from half an hour to an hour, according to the coarseness of the alloy. The roasting may be conducted first with borax and nitre to effect partial separation, when the crucible may be removed from the fire, and the metals allowed

to cool gradually. The crucible may then be broken, and the button of gold at the bottom removed and separated from the slag that covers it with a hammer. The button is then put into a fresh crucible and re-melted. If there is any known base metal present likely to render the gold brittle, the particular re-agent which will most readily attack it may now be used. If, however, as is generally the case, the alloy is of uncertain composition, or contains various metals having distinct affinities, the process becomes, to some extent, experimental, and it may become necessary to use first one refining agent and then another, until sufficient separation is effected. Generally, it will be sufficient to use the nitrate of potassa alone, as most metals are oxydable. After roasting with nitre for half or three-fourths of an hour, adding small portions at a time, the melted metals may be poured into ingot moulds previously warmed and oiled. If, after hammering, annealing, and rolling the ingot, it should still be found brittle, it must be remelted, and chloride of mercury used as the refining agent. This will remove any traces of tin which may be present.

If the alloy, however, is greatly impoverished, it may be more advantageously treated with sulphuret of antimony; in which case the metals should be melted in a large crucible with about twice or three times their weight of the native sulphuret, which should be added in small quantities at a time. The heat decomposes the sulphuret of antimony; the sulphur uniting with the base metals forming sulphurets, and the antimony uniting with the gold forming a leaden-colored alloy. The antimony may be parted from the gold alloy in the following manner: Place the mixture in a clean crucible, and when melted, force a current of air with a pair of bellows upon its surface; this oxydizes the antimony, which passes off in the form of vapor. The current should be mild at first, as too great a draught is apt to carry off portions of gold by a too hurried volatilization of the antimony. A current strong enough to produce visible fumes will be sufficient.

When these cease, the crucible may be covered, and as the melting point of the gold rises with the escape of antimony, the fire should be urged to a stronger heat, and before pouring, a forcible current of air should again be thrown upon the surface of the melted metals to effectually dissipate any remaining portions of the antimony.

If, after treatment with the re-agents enumerated, the alloy should be found malleable, but stiff or elastic, and dull-colored, it is probably due to the presence of platinum; and any further attempts to reduce it by roasting will prove unavailing. It must then be subjected to the process which will be hereafter described for the separation of gold and platinum.

When it is desired to reduce the alloy to pure gold, which is generally advisable whenever the gold to be refined consists of very coarse filings, fragments of plate containing large quantities of solder, linings with platinum pins attached, particles of base metals, etc., the "humid process," as it is called, should be employed. The solvents in common use for this purpose are the nitric, sulphuric, and nitro-muriatic or hydrochloric acids; but as the desired results can be more conveniently and directly obtained by the use of the latter, or hydrochloric acid, this most available method alone will be given. The following practical remarks on the process are copied from an article on the "Management of Gold,"* by Professor George Watt.

"When the alloy is composed of metals differing but little in their affinities for oxygen, chlorine, etc., we resort to one of the 'wet methods.' And, in connection, we will only describe the one which we consider the most convenient and effectual for the practical dentist. It is effectual in all cases, as it always gives us pure gold.

"Let us, then, suppose that our gold alloy has become contaminated with platinum to such extent that the color and elasticity of the plate is objectionable. The alloy should be

* Dental Register of the West, vol. xii. p. 251.

dissolved in nitro-muriatic or hydrochloric acid, called *aqua regia.* The best proportions for aqua regia are three parts of hydrochlorie acid to one of nitric. If the acids are at all good, four ounces of the aqua regia will be an abundanee for an ounce of the alloy. The advantage of using the acids in the proportion of three to one, instead of two to one, as directed in most of the text books, is, that when the solution is completed, there is but little, if any, exeess of nitric acid. If the aeids be "chemically pure," four parts of the hydrochloric to one of the nitrie, produces still better results.

"By this proeess the metals are all converted into ehlorides; and, as the ehloride of silver is insoluble, and has a greater specific gravity than the liquid, it is found as a grayish-white powder at the bottom of the vessel. The ehlorides of the other metals, being soluble, remain in solution. By washing and pouring off, allowing the chloride of silver time to settle to the bottom, the solution may be entirely separated from it. The object is now to preeipitate the gold while the others remain in solution. This precipitation may be effeeted by any one of several different agents, but we will mention only the proto-sulphate of iron.

"This salt is the eommon green eopperas of the shops, and, as it is always eheap and readily obtained, we need look no farther. It should be dissolved in clean rain-water, and the solution should be filtered, and allowed to settle till perfectly clear. Then it is to be added gradually to the gold solution as long as a preeipitate is found, and even longer, as an excess will the better insure the preeipitation of all the gold. The gold thus preeipitated is a brown powder, having none of the appearanees of gold in its ordinary state. The solution should now be filtered, or the gold should be allowed to settle to the bottom, where it may be washed after pouring off the solution. It is better to filter than decant in this ease, as, frequently, partieles of the gold float on the surface, and would be lost in the washings by the latter process.

"Minute traces of iron may adhere to the gold thus pre-

cipitated. These can be removed by digesting the gold in dilute sulphuric acid; and, when the process is properly conducted, thus far, the result is *pure gold*, which may be melted, under carbonate of potash, in a crucible lined with borax, and reduced to the required carat."

CHAPTER IV.

ALLOYS OF GOLD FOR DENTAL PURPOSES.

Gold, in its pure state, is rarely employed by the dentist in laboratory processes on account of its softness and flexibility; it is, therefore, usually alloyed with such metals as impart to it—without practically impairing either its malleability, pliancy or purity—the degree of hardness, strength and elasticity necessary to resist the wear and strain to which an artificial piece constructed from it is unavoidably exposed in the mouth.

Reducing Metals.—The metals with which gold is usually combined are copper and silver. It is sometimes reduced with silver alone, many regarding the introduction of copper into the alloy as objectionable, as plate derived from it is supposed to be more readily tarnished and to communicate to the mouth a disagreeable metallic taste. This is unquestionably true, if, as is sometimes the case, the copper used is in excess; when, in addition to the effects mentioned, gold, so debased, may become a source of positive injury to the organs of the mouth, as well as to the general health. The small proportions of copper usually employed in forming gold plate, however, are not likely to produce, in any objectionable degree, the consequences complained of, unless the fluids of the mouth are greatly perverted. If gold coin is used in the formation of plate, it may be sufficient to add silver alone, inasmuch as copper is already present; though, usually, additional quantities of the latter metal are added.

Required Fineness of Gold Plate.—Alloys of gold to be permanently worn in the mouth, should be of such purity as will most certainly, under all the contingencies of health and

disease, resist any chemical changes that would tend to compromise either the comfort or health of the patient. Evils of no inconsiderable magnitude are sometimes inflicted, either through ignorance, carelessness or cupidity, by disregard of this important requirement. If the general health of the patient remained always uniformly unimpaired, with the secretions of the mouth in their normal state, gold degraded to eighteen or even sixteen carats fine, would undergo no material changes in the mouth. But it must be remembered that, in addition to the corrosive agents introduced into the mouth from without, a variety of diseases, local and constitutional, effect important changes in the otherwise bland and innoxious fluids contained therein, which, from being alkaline or neutral, become more or less acidulated. Indigestion, with acid eructations; gastro-enteritis; ague; inflammatory and typhoid fevers; brain affections; eruptive diseases; rheumatism; gout, &c., are some of the local and constitutional disorders almost uniformly imparting to the mucous and salivary secretions an acid re-action. These readily attack the impoverished gold too frequently employed as a base for artificial teeth; and as a natural sequence to such practice we find supervening, inflammation of the mucous membrane and gums, with chronic periodontitis and loosening of the teeth; apthous ulcers; gastric irritation; general nervous disorders; decay of the teeth; fœtid breath; disagreeable metallic taste in the mouth, &c. Gold plate intended to be introduced into the mouth, should not, therefore, as a general thing, be of a less standard of fineness than twenty carats. It may exceed this degree of purity in some cases, but will rarely or never, unless alloyed with platinum, admit of being used of a higher carat than the present American coin, which is 21·6 carats fine.

Formulas for Gold Plate used as a Base for Artificial Dentures.—Any of the following formulas may be employed in the formation of gold plate to be used as a base or support for artificial dentures. The relative proportions of the alloying

components may be varied to suit the peculiar views or necessities of the manipulator. The estimated carat of the appended formulas are based on the fineness of the American gold pieces coined in 1837 and thereafter.

GOLD PLATE EIGHTEEN CARATS FINE.

Formula No. 1.

18 dwts. pure gold,
4 dwts. fine copper,
2 dwts. fine silver.

Formula No. 2.

20 dwts. gold coin,
2 dwts. fine copper,
2 dwts. fine silver.

GOLD PLATE NINETEEN CARATS FINE.

Formula No. 3.

19 dwts. pure gold,
3 dwts. copper,
2 dwts. silver.

Formula No. 4.

20 dwts. gold coin,
25 grs. copper,
40+ grs. silver.

GOLD PLATE TWENTY CARATS FINE.

Formula No. 5.

20 dwts. pure gold,
2 dwts. copper,
2 dwts. silver.

Formula No. 6.

20 dwts. gold coin,
18 grs. copper,
20+ grs. silver.

GOLD PLATE TWENTY-ONE CARATS FINE.

Formula No. 7.

21 dwts. pure gold,
2 dwts. copper,
1 dwt. silver.

Formula No. 8.

20 dwts. gold coin,
13+ grs. silver.

Formula No. 9.

20 dwts. gold coin,
6 grs. copper.
$7\frac{5}{7}$ grs. platinum.

GOLD PLATE TWENTY-TWO CARATS FINE.

Formula No. 10.

22 dwts. pure gold,
1 dwt. fine copper,
18 grs. silver,
6 grs. platinum.

The union of platinum with gold, as in Formula No. 10, furnishes an alloy rich in gold, while it imparts to the plate derived from it a reasonable degree of stiffness and elasticity; preserves in a good degree the characteristic color of fine gold; and does not materially impair its susceptibility of receiving a high polish. The amount of gold coin given in Formula No. 9 may be reduced with platinum alone, adding to it from eight to twelve grains; in which case, although the carat of the alloy is lowered, its absolute purity remains unaffected, and plate formed from it will better resist any changes in the mouth than gold coin itself.

Formulas, for Gold Plate used for Clasps, Wire, Stays or Linings, Metallic Pivots, &c.—Gold used in the formation of clasps, stays, &c., is improved for these purposes by the addition of sufficient platinum to render it firmer and more elastic than the alloys ordinarily employed in the formation of plate as a base. The advantages of this elastic property, in its application to the purposes under consideration, are, that clasps formed from such alloys will adapt themselves more accurately to the teeth, as, when partially spread apart on being forced over the crowns, they will spring together again and accurately embrace the more contracted portions. In the form of stays or backings, additional strength being imparted, a less amount of substance will be required; the elasticity of these supports, also, will not only lessen the chances of accident to the teeth themselves in mastication and otherwise, but preserve their proper position when temporarily disturbed by any of the forces applied to them. The same advantages last mentioned are obtained from this property in the use of metallic pivots.

Formula No. 1.	*Formula No.* 2.
20 dwts. pure gold,	20 dwts. coin gold,
2 dwts. fine copper,	8 grs. fine copper,
1 dwt. fine silver,	10 grs. silver,
1 dwt. platinum.	20 grs. platinum.

The alloy derived from either of these formulas will be twenty carats fine.

Gold Solders.—Solders are a class of alloys by means of which the several pieces of the same or of different metals are united to each other. They should be more fusible than the metals to be united, and should consist of such components as possess a strong affinity for the substances to be joined. They should also be as fine as the metals to which they are applied will admit of without endangering the latter. Solders of different degrees of fineness, therefore, should always be provided, from which the one most suitable for any given case may be selected.

The use of solders of doubtful or unknown composition should be avoided, and hence they should be compounded either from pure gold or gold coin.

The following formula taken from Prof. Harris' work on "Dental Surgery," page 664, recipe No. 3, may be used in connection with eighteen or twenty carat gold plate, and is sixteen carats fine.

6 dwts. pure gold,
2 dwts. roset copper,
1 dwt. fine silver.

Recipes Nos. 1 and 2, page 663 of same work, are too coarse to be introduced into the mouth; the former being a fraction below fourteen carats, while the latter is still more objectionable, exceeding but little twelve and one-half carats.

Formula No. 1 of the following recipes is a fraction over fifteen carats fine; and No. 2 furnishes a solder eighteen carats fine.

Formula No 1.	*Formula No*. 2.		
6 dwts. gold coin,	Gold coin,	30	parts.
30 grs. silver,	Silver,	4	"
20 grs. copper,	Copper,	1	"
10 grs. brass.	Brass,	1	"

Zinc, as will be observed by the incorporation of brass in the above formulas, is sometimes employed, principally with a

view of rendering the alloy more fusible. Its employment under any circumstances is objected to by many on the ground that it more readily tarnishes in the mouth, is more brittle, and furnishes more favorable conditions for galvanic action. These objections only hold good when zinc is used in excess. When employed in quantities sufficient only to make the gold flow readily and evenly at a diminished heat, it is claimed that the base metal used in these alloys is chiefly consumed in the process of soldering, leaving a residuum of gold equal, or nearly so, in fineness to the plate. If such is the case, they are desirable alloys for soldering purposes, inasmuch as the importance of having the various parts of a piece of dental mechanism differ as little as possible in their affinity for the acids of the mouth is generally recognized.

Method of reducing Gold to a lower or higher standard of Fineness, and of determining the Carat of any given Alloy.— In the process of compounding gold for dental purposes, the manipulator should always aim at exactness in the quantity and relative proportions of the reducing components, and should be able to determine precisely the purity of the metals he employs. Gold alloys are too often arbitrarily compounded, and used without any adequate knowledge of their quality or properties; and formulas, taken on trust, are employed without any certain knowledge of the quality of the alloys they produce.

That we may know certainly the quality of the gold alloys used in the laboratory without resorting to the inconvenient process of analysis or assaying, they should always be made either from pure gold or gold coin, the standard of these being definitely fixed. But as the process of procuring pure gold is somewhat tedious and troublesome, gold coin is very generally employed for the purpose. The amount of alloy necessary to reduce either pure or coin gold to any particular standard, whether higher or lower, and the method of ascertaining the carat or fineness of any given alloy, may be readily determined by a few simple rules. The following

practical remarks on the method are copied from an article on "Alloying Gold,"* by Professor G. Watt.

"1. *To ascertain the carat of any given alloy.*—The proportion may be expressed as follows:

"As the weight of the alloyed mass is to the weight of gold it contains, so is 24 to the standard sought. Take, for example, Harris' No. 3 gold solder:

Pure gold, . . .	6 parts.
" silver, . . .	2 "
" copper, . . .	1 "
Total, ...	9

"The proportion would be expressed thus,—

9 : 6 : : 24 : 16.

"From this any one can deduce the following

"Rule.—Multiply 24 by the weight of gold in the alloyed mass, and divide the product by the weight of the mass; the quotient is the carat sought.

"In the above example, 24 multiplied by 6, the quantity of gold, gives 144, which, divided by 9, the weight of the whole mass, gives 16. Hence, an alloy prepared as above, is 16 carats fine.

"As another example, under the same rule, take Harris' No. 1 solder.

22 Carat gold, . . .	48 parts.
silver, . . .	16 "
copper, . . .	12 "
Total, ...	76

"Now, as the gold used is but 22 carats fine, one-twelfth of it is alloy. The one twelfth of 48 is 4, which subtracted from 48, leaves 44. The statement then is:

76 : 44 : : 24 : 13·9.

"This solder, therefore, falls a fraction below 14 carats.

* Dental Register of the West, vol. x. p. 396.

"2. *To reduce gold to a required carat.*—The proportion may be expressed as follows:

"As the required carat is to 24, so is the weight of the gold used to the weight of the alloyed mass when reduced. The weight of gold subtracted from this, gives the quantity of alloy to be added.

"For example, reduce 6 ounces of pure gold to 16 carats.

"The statement is expressed thus:

$$16 : 24 :: 6 : 9.$$

"Six subtracted from 9 leaves 3, which is the quantity of alloy to be added. From this is deducted the following

"RULE.—Multiply 24 by the weight of pure gold used, and divide the product by the required caret. The quotient is the weight of the mass when reduced, from which subtract the weight of the gold used, and the remainder is the weight of alloy to be added.

"As another example under the same rule, reduce 1 pennyweight of 22 caret gold to 18 carets.

"As the gold is only 22 carets fine, one-twelfth of it is already alloy. The one pennyweight, therefore, contains but twenty-two grains of pure gold. The statement is, therefore, thus expressed:

$$18 : 24 :: 22 : 29\tfrac{1}{3}.$$

"Twenty-two subtracted from $29\frac{1}{3}$ leaves $7\frac{1}{3}$. Therefore, each pennyweight of 22 caret gold requires $7\frac{1}{3}$ grains of alloy to reduce it to 18 carets.

"3. *To reduce gold from a lower to a higher caret.*—This may be done by adding pure gold, or a gold alloy finer than that required. The principle of the rule may be set forth in the following general expression:

"As the alloy in the required caret is to the alloy in the given caret, so is the weight of the alloyed gold used, to the weight of the reduced alloy required. This principle may be practically applied by the following:

RULE.—Multiply the weight of the alloyed gold used by

the number representing the proportion of alloy in the given caret, and divide the product by that representing the proportion of alloy in the required caret; the quotient is the weight of the mass when reduced to the required caret by adding fine gold.

"To illustrate this, take the following example:

"Reduce 1 pennyweight of 16 caret gold to 18 carets.

"The numbers representing the proportions of alloy in this example are found by respectively subtracting 18 and 16 from 24. The statement is, therefore:

$$6 : 8 :: 1 : 1\tfrac{1}{3},$$

from which it follows that to reduce one pennyweight of 16 caret gold to 18 carets, there must be one-third of a pennyweight of pure gold added to it.

"But, suppose that, instead of pure gold, we wish to effect the change by adding 22 caret gold. The numbers, then, respectively representing the proportions of the alloy would be found by subtracting, in the above example, 16 and 18 from 22, and the statement would be

$$4 : 6 :: 1 : 1\tfrac{1}{2}.$$

"It follows, then, that to each pennyweight of 16 caret gold, a half pennyweight of 22 caret gold must be added to bring it to 18 carets.

"By the above rules we think the student will be able, in all cases, to calculate the fineness or quality of his gold, and to effect any reduction, whether ascending or descending, which he may desire."

To facilitate the student in accurately compounding gold alloys from coins of that metal, the following table, giving the weight in grains, fineness, and the value of the gold coins of different nations, is given in this connection.

Table of Coinage of Different Nations.

Nations.		Weight.	Fineness.	Value.
		Grains.	Thous.	d. c. m.
Argentine Republic.				
Doubloon, Province of Rio de la Plata,	1828–32	418	815	14 66
" " "	1813–32	415	868	15 51
The same variation of fineness and weight in coins of the same date are to be found in the silver coinage of this republic.				
Austria.				
Ducat of Maria Theresa,	1762	53·5	965	2 26 9
Sovereign of Maria Theresa,	1778	170	917	6 71 3
Ducat of Leopold II.,	1790	53·5	986	2 27 2
" of Francis I.,	1809–34	53·7	983	2 27 4
Quadruple of Francis I.,	1830	215·5	983	9 12 2
Sovereign of Francis I.,	1831	174·5	898	6 74 8
" of Ferdinand I.,	1838	174·5	901	6 77 1
Half-sovereign of Ferdinand I.,	1839	87	902	3 38
Ducat of Ferdinand I.,	1838	53·7	985	2 27 8
Quadruple of Ferdinand I.,	1840	215·5	985	9 14
Hungary ducat of Ferdinand I.,	1839	53·7	986	2 28 1
Baden.				
Ten guilder (five guilder same quality) of Louis, Grand Duke,	1819	105·5	900	4 08 6
Bavaria.				
Ducat of Maximilian Joseph and Charles Theodore,	1764–97	53	980	2 23 7
Ducat of Maximilian Joseph II.,	1800	53	984	2 24 6
" of Louis,	1832	53·5	987	2 27 4
Belgium.				
Forty francs,		199	895	7 67
Twenty francs in proportion, same fineness. Sovereigns same as Austrian coinage.				
Bolivia.				
Doubloon,	1827–36	416·5	870	15 58
Brazil.				
Moidore of Maria I. and John III.,	1779	125·5	914	4 94
Half-Joe of Peter II.,	1833–38	221·5	915	8 72 7
The other moidores and half-joes are of the same fineness with the moidore of 1779, varying slightly in weight.				
Britain.				
The gold coins of this kingdom are of the uniform fineness of 915·5, but below the legal standard about one-thousandth. The par value of the pound sterling is about $4.84. Sterling gold is worth 94·6 cents per pennyweight.				
Brunswick.				
X. Thaler of Charles,	1745	202	898	7 81 2
" of Charles William Ferdinand,	1805	204	896	7 87 2
" of Wm. Fred. and George, Regent,	1813–19	204·5	896	7 89 1
" of Charles,	1824–30	205	896	7 91
" of William,	1831–38	205	894	7 89 3
V. Thaler of Charles,	1748–64	102	903	3 96 6

Table of Coinage of Different Nations.—*Continued.*

Nations.		Weight.	Fineness.	Value.
		Grains.	Thous.	d. c. m.
Central America.				
Doubloons,	1824–33	417	833	14 96
Chili.				
Doubloons,	1819–24	417	867	15 57
"	1835 and seq.	417	872	15 66
Colombia.				
Doubloon of eight escudos, Colombia, Bogotan Mint,	1823–36	416 8	870	15 61 7
" " Popayan Mint,	1823–36	416·5	858	15 39
" of New Granada, Bogota,	1837	416 8	870	15 61 7
Half-doubloon of Ecuador, Quito,	1836	209	844	7 59 6
Quarter-doubloon of Colombia, Bogota,	1823–35	104	865	3 87 4
" of Ecuador, Quito,	1835	104	844	3 78
Eighth-doubloon of Colombia, Bogota,	1823–36	51	865	1 90
" " Popayan,		51	852	1 87 1
These last coins vary in fineness from 849 to 854, and in weight from 44½ to 61½. The sixteenth-doubloons are of the same quality.				
Denmark.				
Specie ducat of Frederick V.,	1749	53·5	988	2 27 6
" of Christian VII.,	1795–1802	53 7	979	2 26 4
Current ducat of Christian VII.,	1783	48	876	1 81 1
Christian d'or of Christian VII.,	1775	103	905	4 01 4
Double Frederick d'or of Frederick VI.,	1813–39	204·5	895	7 88 2
Egypt.				
Sequin fundoukli of Achmet III.,	1115 (1703)	53	958	2 13 7
" of Mahmoud I.,	1143 (1730)	39	940	1 57 9
" "	"	39	848	1 42 4
" of Mustapha III.,	1171 (1757)	39	781	1 31 2
" of Abdul Hamed,	1187 (1773)	39	786	1 32
" "	"	39	645	1 08 3
" of Salim III.,	1203 (1789)	39	690	1 15 9
Half-sequin fundoukli of Mahmoud II.,	1233 (1818)	18	670	51 9
Bedidlik, 100 piastres, of Abdul Majeed,	1255 (1839)	132·2	874	4 97 6
Nusflix, 50 piastres, "	"	66·1	875	2 49 1
Kairia Hastreen, 10 piastres, "	"	27	874	1 01 7
The first date given above is the year of the Hegira; the second, the Christian era.				
France.				
Louis d'or of Louis XV.,	1726–73	124	897	4 79
" of Louis XVI.,	1786–92	116 5	900	4 51 6
Double Louis d'or of Louis XV.,	1744	250	902	9 71 1
" of Louis XVI.,	1786–92	235	901	9 11 9
Napoleon, 20 francs, of Napoleon,	1803–14	99 2	899	3 84 1
The subsequent gold coinage of France is of the uniform fineness of 899, except the twenty franc pieces of Louis Phillippe, coined in 1840–41, which are 900.				
Greece.				
Twenty drachms of Otho,	1833	89	900	3 45
Hanover.				
Ducat of George III.,	1776	53·5	993	2 28 8

TABLE OF COINAGE OF DIFFERENT NATIONS.—*Continued.*

NATION.		Weight.	Fineness.	Value.
		Grains.	Thous.	d. c. m.
HANOVER.—*Continued.*				
Pistole or five thaler of George III.,	1803	102	896	3 93 6
" " "	1813–14	102	890	3 91
Ten thaler of George III.,	1813–14	204 5	890	7 83 8
" William IV. and Ernst. August. 1835 and seq.		205	895	7 90 2
HESSE.				
Ten thaler of Frederick II.,	1773–85	202	890	7 74 2
Five thaler of Frederick II.,	1771–84	101	893	3 88 4
" of William IX.,	1788–89	101 5	892	3 89 9
" of William I.,	1815–17	101·5	894	3 90 8
HINDOSTAN.				
Mohur of Bengal,	1770	190	982	8 03 5
" "	1787	191	989	8 13 4
" "	1793	191	993	8 16 8
" "	1818	204·7	917	8 08 4
" of Madras,	1818	180	917	7 10 9
" of Bombay,	1818	179	920	7 09 2
Half-mohur of Bengal,	1787	95	984	4 02 6
Star pagoda of Madras,		52·5	800	1 80 9
Pondicherry pagoda of Pondicherry,		52 5	708	1 60 1
Porto Novo pagoda of Portuguese Company,		52 5	740	1 67 3
MECKLENBURG SCHWERIN.				
Ten thaler of Frederick Francis,	1831	204·5	896	7 89 1
MEXICO.				
Dublooon of Mexico, Augustiu, Emperor,	1822	416 5	864	15 49 8
" " Mexican Republic,	1824–30	416 5	865	15 51 6
Other doubloons minted at Mexico weigh 417 grains, and are from 867 to 869 thousandths fine. The doubloon of Guanaxuato varies from 860 to 867 in fiueuess.				
Doubloon of Durango.		417	868	15 58 8
" "		417	865	15 53 4
" "	1833–36	417 5	872	15 67 9
" of Guadalaxara,		416	865	15 49 7
MILAN.				
Zecchino, or Sequin, of Maria Theresa and Joseph II.,	1770–84	53 5	990	2 28 1
Doppia, or Pistole, of Joseph II ,	1783	97 5	908	3 81 3
Forty lire of Napoleon,	1805–14	199	899	7 70 6
Sovereign of Francis I.,	1831	174 5	898	6 74 8
" of Ferdinand I.,	1838	174·5	901	6 77 1
Half-sovereign,	1839	87	902	3 38
NAPLES AND SICILY.				
Six ducat, of Ferdinand IV.,	1783	135	893	5 19 2
Onzia of Sicily of Charles,	1751	68	959	2 51 6
Onzia of Ferdinand I.,	1818	58	995	2 48 5
Twenty lire of Joachim Napoleon,	1813	99	900	3 84 8
NETHERLANDS.				
Ducat,	1770–1810	53 5	980	2 25 8
" of William I.,	1833–39	53 7	981	2 26 9
Ten guilders of William I.,	1816–39	103.5	899	4 00 7

TABLE OF COINAGE OF DIFFERENT NATIONS.—*Continued.*

NATION.		Weight.	Fineness.	Value.
		Grains.	Thous.	d. c m.
PERSIA.				
Toman of Fatha Ali Shah, Kajar,	1230–40 (1814–24)	71·2	991	3 04 2
" of Mohammed Shah, Shakinshah,	1255 (1839)	53 7	965	2 23 3
Half-toman of Mohammed Shah,	1252 (1837)	27	968	1 12 1
POLAND.				
Ducat of Stanislaus Augustus,	1791	53 5	984	2 26 6
PORTUGAL.				
Moidore of Peter II.,	1689	165	908	6 45 2
" "	1705	165	928	6 59 4
" of John V.,	1714–26	165	913	6 48 8
Half-joe,	1727–77	217	914	8 62
" of Maria I. and Peter III.,	1778–85	220	913	8 65
" of Maria I.,	1787–1804	221	914	8 69 9
" of John VI.,	1822–24	221	909	8 65 2
Joannese of John V.,	1730	439	912	17 24 2
Crown of Maria II.,	1838	148	912	5 81 3
PRUSSIA.				
Frederick d'or of Frederick II.,	1752–82	102	901	3 95 8
" of Frederick William II.,	1795–96	102	897	3 94
" of Frederick Wilhelm III.,	1799–1812	102	901	3 95 8
Double Frederick d'or of Fred. Wilhelm III.,	1800–11	205	898	7 92 3
" " "	1831	205	903	7 97 2
Ducat of Frederick William II.,	1787	53 5	979	2 25 6
ROME.				
Sequin of Pius VI.,	1775–83	52·5	996	2 25 2
Doppia of Pius VI.,	1777–86	84	906	3 27 8
" of Pius VII.,		84·5	901	3 27 9
Gold scudo of Republic,	1799	910	833	32 64 6
Ten scudi of Gregory XVI.,	1836	267 5	900	10 36 8
RUSSIA.				
Imperial of Elizabeth,	1756	253	915	9 97
The gold coins of Russia, though irregular in weight, are of the same standard fineness during the reigns of Elizabeth and Catharine II.				
Ducat of Paul I.,	1798	66	969	2 75 4
Three roubles of Nicholas,	1838	60·5	917	2 38 9
Half-imperial of Nicholas,	1839	100·5	917	3 96 9
SARDINIA.				
Pistole of Victor Amadeus, &c.,		148	905	5 76 8
Carlino (island) of Victor Amadeus, &c.,	1773	247	890	9 46 7
Marengo of Republic,	1800	98	898	3 79
Eighty lire,		398	898	15 39 2
Genovine of Ligurian republic (Genoa)	1798	388	908	15 17 2
SAXONY.				
Double August d'or of Fred. August. III.,	1784–1817	204 5	896	7 89 1
" " "	1826	205	898	7 92 8
Double Anton d'or of Anthony,	1830–36	205	900	7 94 6
Ducat of Anthony,	1830	53 7	979	2 26 4

TABLE OF COINAGE OF DIFFERENT NATIONS.—*Continued.*

NATION.		Weight.	Fineness.	Value.
		Grains.	Thous.	d. c. m.
SPAIN.				
Cob doubloon of Philip V., American,	1733–44	416	895*	16 03 4
Doubloon of Ferdinand VI., American,	1751	416	908	16 26 5
" of Charles III., American,	1772–84	416	843†	16 00
" of Charles III., Spanish,	1786–88	416	890	15 58 7
" of Charles IV. and Ferdinaud VII., Americau,	1789–1821	416·5	868	15 57
Pistole of Philip V., Spanish,	1745	103	909	4 63 2
" of Charles III., American,	1774–82	103	895	3 97
" of Ferdinand VII., American,	1813–24	104	872	3 90 6
Escudo of Charles III.. Spanish,	1786–88	52	874	1 95 7
" of Charles IV.,	1789–1808	52	868	1 94 4
" of Ferdinand VII , American,	1809–20	52	851	1 90 6
Half-doubloon of Charles III., Spanish.	1780–82	206	896	7 95
" of Charles IV , American,	1789–1808	208	870	7 79 3
" of Ferdinand VII., Spanish,	1810–24	208	865	7 74 8
SWEDEN.				
Ducat of Gustavus III. and Gustavus IV.,	1777–1800	53	977	2 23
" of Charles John XIV.,	1838	54	975	2 26 7
SWITZERLAND.				
Pistole of Berne,	1796	116	901	4 50 1
" of Basle,	1795	118	891	4 52 8
" of Soleure,	1798	116	898	4 48 6
" of Helvetian Republic,	1800	116	897	4 48 1
Ducat of Berne,	1794	52·5	974	2 20 2
" of Basle,		53	943	2 15 2
TUNIS.				
Half-sequin of Abdul Hamed,	1773	19	885	72 4
TURKEY.				
Sequin fondouk of Selim III.,	1789	52·5	800	1 80 9
" zermahboub of Selim III.,	1789	36	800	1 24
Ohikilik of Mahmoud II.,	1822–24	25	833	89 7
Twenty piasters, of Mahmoud II.,	1827	27·5	875	1 03 7
Yirmilik, 20 piasters of Abdul Medjid,	1840	24·5	832	87 7
TUSCANY.				
Ruspone of Francis III. to Leopold III.,	1738–1800	160	997	6 87
" of Louis I. and Charles I.,	1801–07	161	998	6 91 9
" of Leopold II.,	1824–34	161	999	6 92 5
Sequin of Leopold.	1765–79	53	997	2 27 6
" of Leopold II.,	1824–34	53 5	999	2 30 1
UNITED STATES.				
Eagle,	1792–1834	270	916 7	10 67 4
"	1834–37	258	899 2	9 99 7
"	1837 aud seq.	258	900	10
WURTENBURG.				
Ducat of Charles.	1790–1818	53	980	2 23 7

* Varies from 893 to 898. † Varies from 883 to 893, the oldest pieces being the best.

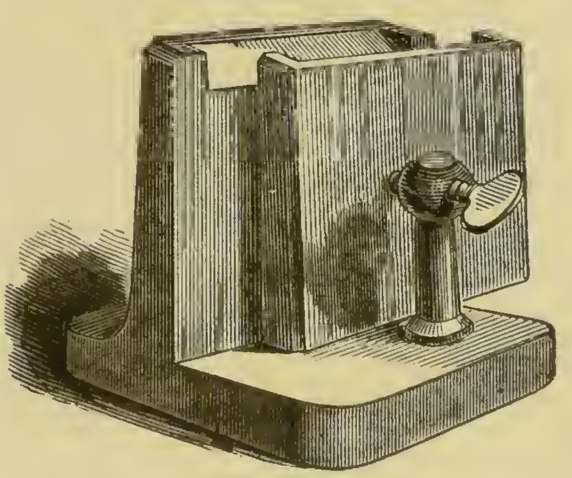
CHAPTER V.

METHOD OF CONVERTING GOLD ALLOYS INTO THE REQUIRED FORMS FOR DENTAL PURPOSES.

Manner of procuring an ingot.—The gold, with its alloying constituents, is put into a clean crucible, lined on the inside with borax, and placed in the furnace. When the contained metals are perfectly fused, the crucible should be removed from the fire with a pair of tongs, and the contents poured quickly but carefully into the ingot molds; the latter being placed conveniently near the mouth of the furnace, as the molten metals soon become chilled on exposure to the open air. Before pouring, the molds, if made of iron, should be moderately heated and oiled, or coated with lamp-smoke by holding their inner surfaces over the flame of an oil lamp or gas jet.

Ingot molds are constructed of various substances, but those in most common use, and at the same time most convenient, are formed of iron; and for gold, are generally about two inches square, and from one-eighth to one-sixth of an inch thick. (Fig. 13.) They should be slightly concave on their inner surfaces to compensate for the greater shrinkage of the gold in the centre than at the margins of the ingot.

Fig. 13.



Soapstone is sometimes employed for the same purpose, and is preferred by many. It should also be warmed and oiled before pouring the metals. Molds made from charcoal are also sometimes used, but as they require to be frequently renewed, are not generally employed. Molds are formed from this latter substance by selecting two pieces with even surfaces, or dividing a single piece with a saw, when either the required size and shape of the mold may be cut out in one half, or a strip of sheet iron, a little broader than the required thickness of the ingot, being bent into proper form, is placed between, and the edges partially imbedded in, the two pieces of charcoal and the latter secured by binding them together with wire. Molds made from this material do not require to be either heated or oiled.

It not unfrequently happens that, at the first pouring, the metals arrange themselves in the ingot in accordance with the density of the several components; those of greater specific gravity passing to the bottom, and the lighter metals remaining above. Whenever this occurs, the ingot must be broken into pieces and re-melted; this should be repeated, if necessary, until the alloy assumes a perfectly homogeneous appearance. It should then be annealed in hot ashes, which softens the gold and removes the adhering grease.

Forging.—Before laminating the ingot, it should be reduced somewhat in thickness by placing it on an evenfaced anvil or other equally smooth and resistant surface, and subjecting it to repeated blows with a tolerably heavy hammer. It should be frequently annealed, and the process of forging continued, alternately hammering and annealing, until the ingot is reduced one-half or more in thickness.

Laminating or rolling.—The reduced ingot, well annealed, is next laminated or spread out into a sheet of greater or less thinness by passing it repeatedly between two strong, highly polished, cylindrical steel rollers. The mills used for the purpose are variously constructed; the plainest forms (Fig. 14) being very simple in their mechanism, while others, or

Fig. 14.

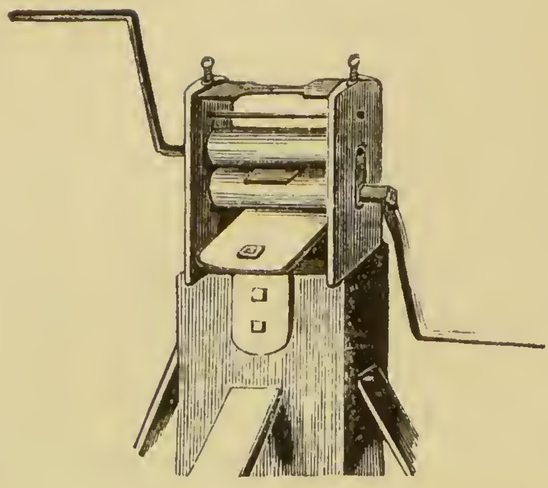
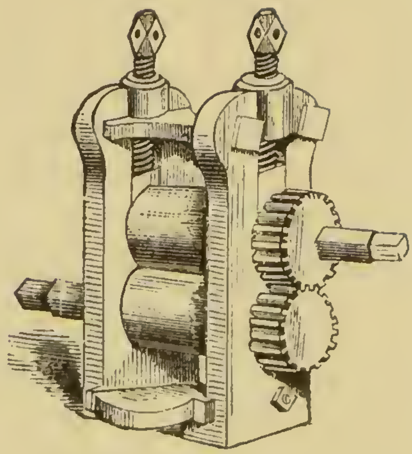
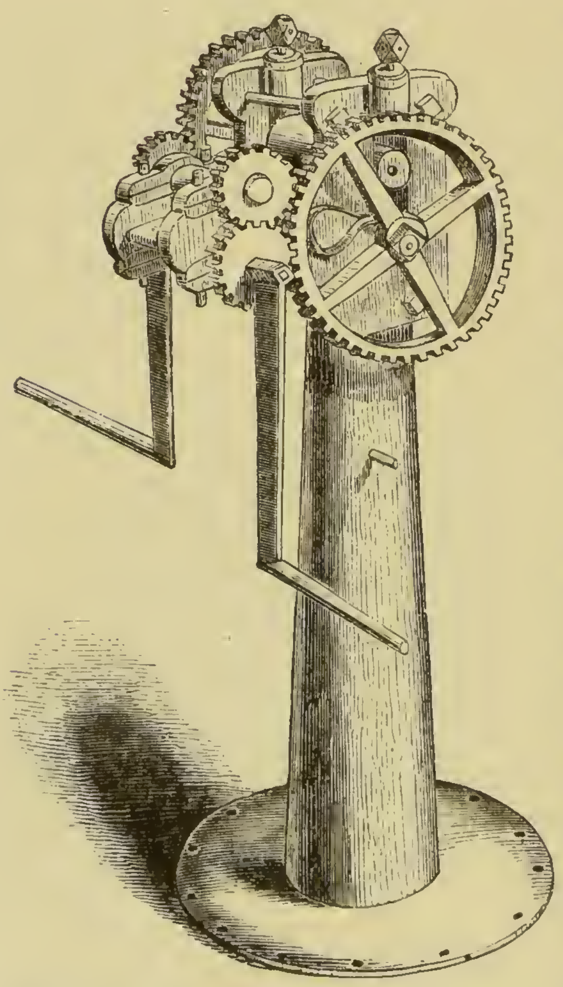


Fig. 15.



geared mills, are more complicated, and are constructed with a view to a greater augmentation of power, and precision, and certainty of action. The latter, (Figs. 15–16,) if of approved pattern, materials and manufacture, are, upon the whole, more economical and reliable than the cheaper varieties. The rollers, for the purposes of the dentist, should be from three to four inches in length.

Fig. 16.



In laminating, the rollers should first be adjusted equi-distant at both ends, and this uniformity, as they are approximated from time to time, should be preserved throughout. At every passage of the gold bar between the rollers, the distance between the latter should be diminished; care being taken that the approximation be not

sufficient to clog or impede the free action of the mills. The gold, which in time becomes hard and brittle and liable to crack in the mills, should be frequently and well annealed by bringing it to a full red heat; this restores the pliancy of the gold and facilitates the operation in the press.

When the ingot has been extended in one direction as far as may be desired, it should always be re-annealed before turning it in the mills; a neglect of this precaution will seriously interfere with the working of the gold by twisting or doubling the plate upon itself; and in some instances, provided the gold has not been well annealed throughout the operation, or is in any considerable degree unmalleable, the plate will be torn across and rendered unfit for use.

A thin or retreating edge may be given to the plate at any desired point or points by passing such portions part way between the rollers and withdrawing; repeating this, with the rollers brought a little nearer to each other every time the plate is introduced between them, and decreasing the distance the plate passes each time until it is reduced to as thin an edge as may be desired.

The degree of attenuation obtained by rolling is determined by what is called a *gauge plate*, (Fig. 17.) This instrument is usually circular or oblong in form, and is marked at intervals on its edge by cross-cut grooves or fissures, which successively diminish in size and are indexed by numbers ranging from 6 to 40. The size of the grooves diminish with the ascending numbers. During the operation of rolling, the plate should be tested, from time to time, by the gauge to determine when it has undergone sufficient attenuation.

FIG. 17.

Thickness of Gold Plate required as a Base for Artificial Dentures.—In prescribing the thickness of plate proper for

the purpose indicated, no estimate can be given that will apply to all cases, as certain conditions of the mouth, to be mentioned hereafter, will suggest some modifications in this respect. Usually, however, plate for entire upper sets should correspond in thickness with number 26 of the guage plate; for the under jaw, number 24 may be used; while for partial upper pieces, an intermediate number may be chosen, unless atmospheric-pressure plates are used, when the number recommended for full upper sets may be employed.

Thickness of Plate for Clasps, Stays, &c.—Plate for these purposes should correspond with from 20 to 22 of the gauge; a less amount of substance, as before stated, being required when the alloy has incorporated with it a small proportion of platinum.

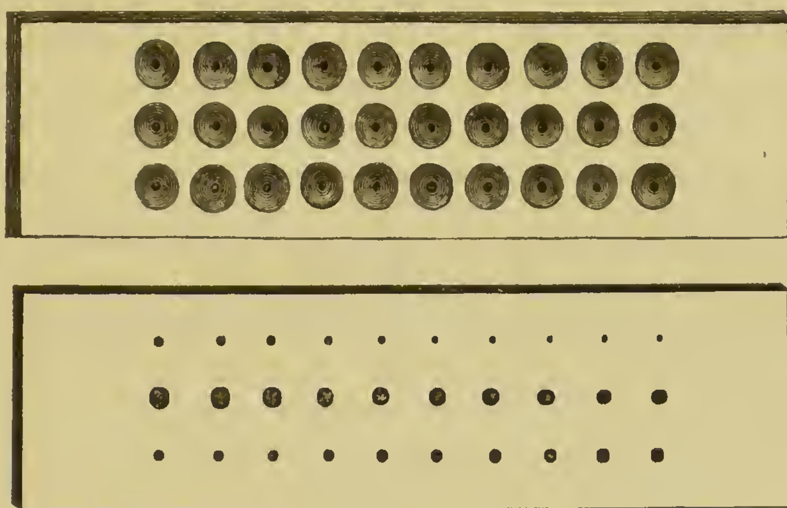
Reduction of Gold Solders into Proper Form for Use.—The method of converting gold solders into the form of plate, does not differ from that already described in the manufacture of plate as a base, except that when zinc or brass is used, the latter should be added after the other constituents are completely fused, and then instantly poured to prevent undue wasting of the base metals by a too protracted heat.

The solder should be reduced to plate somewhat thinner than that used for upper sets, 28 of the gauge-plate. It is customary sometimes to roll the solder into very thin ribbons, but this is objectionable for the reason that a greater amount of the alloying metals being exposed in a given surface to the action of the heat in soldering, are burnt out or oxydated, which interrupts the flow and weakens the attachment between the solder and plate.

Method of Obtaining Gold Wire.—To convert gold or its alloys into the form of wire, the operator should be provided with a draw-plate, a vice, and a pair of hand-pincers. A draw-plate (Fig. 18) is an oblong piece of steel pierced with a regular gradation of holes, or a series of progressively diminishing apertures, through which the gold bar, reduced to a rod, is forced and made to assume the form and dimensions

of the hole through which it is last drawn. The holes are formed with a steel punch, and are enlarged on the side where the wire enters and diminish with a gradual taper to

FIG. 18.



the other side. A *draw-bench* is sometimes employed in extending the wire, the power being applied by a toothed wheel, pinion, and rack work, and is moved by the hands of one or two persons. For the purposes of the dentist, however, it will be sufficient to fix the draw-plate securely between the jaws of a bench-vice, and, by seizing hold of one end of the gold rod with a strong pair of clamps or hand-pincers serrated or cut like a file on the inside of the jaws, the wire may be drawn steadily through the plate, passing from the larger to the smaller holes until a wire of the required size is obtained.

In drawing the wire, the motion should be steady and uniform, for if drawn interruptedly or by jerks, the wire will be marked by corresponding inequalities. The gold rod should also be annealed from time to time, and the holes kept well greased or waxed.

The process described above will answer equally well in reducing any of the ductile metals to wire, as silver, copper, platinum, &c., so that any further description of the method, in connection with these metals, will be unnecessary.

Method of Constructing Spiral Springs.—Inasmuch as spiral springs have been, to a great extent, superseded by more approved agencies employed in the retention of artificial teeth in the mouth, and as all the principal dental furnishing houses are supplied with these appliances already prepared for use, the author does not deem it necessary to enter into a description of the various apparata used in making them.

The following simple contrivance will meet the limited requirements of those who are obliged or prefer to manufacture their own springs. The wire, obtained as already described, is held between two blocks of wood fastened between the jaws of a bench-vice. By means of a small hand-vice, one end of the wire is clamped to a uniformly cylindrical and well-tempered steel rod or wire four or six inches long, and about the size of a small knitting needle, and which being made to revolve while resting on the blocks of wood, the wire is wound firmly and compactly around it producing a uniform coil.

CHAPTER VI.

SILVER.

General Properties of Silver.—Pure silver, when planished, is the brightest of the metals. Fused, or in the form of ingot, its specific gravity is 10·47; but when hammered or condensed in the coining press, its density is increased, and its specific gravity becomes 10·6. It fuses at an extreme red heat, generally estimated at 1·873° Fah. It is remarkably laminable and ductile; yielding leaves not more than $\frac{1}{100000}$ of an inch thick, and wire 400 feet of which may be drawn weighing but a single grain. It exceeds gold in tenacity or cohesion, but is inferior to platinum in this respect. A silver wire ·078 of an inch in diameter will sustain a weight of 187·13 pounds. Fine silver is unaffected by moisture or pure atmospheric air, but is readily tarnished with a film of brown sulphuret by exposure to sulphuretted hydrogen. The sulphuret of silver thus formed may be easily removed by rubbing the metal with a solution of *cameleon mineral*, prepared by calcining equal parts of black or peroxide of manganese and nitre. Unlike gold and platinum, it is readily soluble in nitric acid; this and sulphuric acid being the only simple ones that dissolve it. Silver becomes very brilliant when heated; boils and vaporizes above its fusing point; and when cooled slowly, its surface presents a crystalline appearance.

Alloys of Silver.—Silver combines readily with most metals, forming compounds of variable degrees of malleability, ductility, density, &c.

Tin, zinc, antimony, lead, bismuth and arsenic, render it brittle. A very minute quantity of tin is fatal to the

ductility of silver. Silver does not easily combine with iron, although the two metals may be united by fusion. Gold, copper, platinum, iridium, steel, manganese, and mercury, also form alloys with silver.

An alloy of nine parts of silver and one of copper is the Government standard of the United States coinage since 1837. To this, three cent pieces form an exception; these being composed of three parts silver and two of copper. The coins of silver having a greater average fineness than those of our own country, are Brazil, Britain, Chili, France, Greece, Hindostan, Persia, Portugal, Rome, and Tuscany. A common impression prevails that the Mexican silver coin contains more than an average percentage of silver, and is therefore sought after on account of its supposed purity. This is true of some pieces coined at different periods, but the average fineness of the Mexican, as well as Spanish coins, is exceeded by those of the United States mints.

Reduction of Silver to the Required Forms for Dental Purposes.—Owing to the very soft and flexible nature of silver in its pure state, it is usual, when converting it into plate or other forms for use, to employ an alloy of the metal. Hence silver coins, which are made harder by the copper they contain, are generally selected for the purpose. The employment of silver, thus debased, as a base for dental substitutes is regarded by many as unsafe and injudicious. Although the influences of an alloy so readily acted upon as this by the various agents which affect it chemically, cannot always be certainly predicted in every case, yet no reasonable doubt can be entertained but that, under the favoring conditions which usually exist in the mouth, the evils accruing, directly and indirectly, to the organs of the mouth, and through them to the general system, are positive and undoubted. If used at all, therefore, it should be alloyed with the least practicable amount of copper, or what is better, pure silver should be reduced with platinum alone, in sufficient quantities to impart to the plate an adequate degree of strength and elasticity.

The tendency of silver to tarnish in the mouth when alloyed with copper, may be diminished by boiling the finished piece in a solution of cream of tartar and chloride of soda, or common salt, or by scrubbing it with aqua ammonia, which removes the superficial particles of copper, and exposes a surface of fine silver. When platinum is introduced as the sole alloying component, the purity of the silver is not only preserved, but the alloy is less easily acted on chemically, while the plate derived from it is rendered sufficiently inflexible and elastic. From three to five grains of platinum may be added to one pennyweight of pure silver.

On account of the strong affinity of sulphur for silver, the fuel most proper to be used in melting it is charcoal. The various processes employed in the conversion of silver into the required forms for use are similar to those described for gold, and need not be recapitulated.

Formulas for Silver Solders.—Silver solders are usually composed of silver, copper, and zinc, in variable proportions. Alloys formed from the following formulas are such as are generally employed in soldering silver plate derived from the coins of that metal. Three-cent pieces, composed of two parts silver and one of copper, may also be used for the same purpose.

Formula No. 1.		*Formula No. 2.*	
Silver	66 parts.	Silver	6 parts.
Copper	30 "	Copper	2 "
Zinc	10 "	Brass	1 "

When the material to be united is composed of pure silver and platinum, silver coin alloyed with one-tenth zinc may be used as a solder.

In compounding silver solders, the silver and copper should be first melted, and the zinc or brass afterwards added, when they should be quickly poured to prevent undue waste, by oxydation, of the more fusible component. The ingot when cold, should be rolled into plate a little thicker than that recommended for gold solder.

CHAPTER VII.

PLATINUM AND THE PLATINOID METALS.

PLATINUM is a grayish-white metal, resembling in some measure polished steel. It is harder than silver, and has a density greater than any other known metal, its specific gravity being 21·25. It remains unaltered in the highest heat of a smith's forge, and can only be fused by means of the oxy-hydrogen blow-pipe and galvanism. A white heat does not tarnish it, nor is it in any way affected by exposure either in the air or water. It is insoluble in any of the simple acids; nitro-muriatic acid being the only one that dissolves it. It is sufficiently malleable to be hammered into leaves so thin as to be blown about by the breath. It may be drawn into wire the two-thousandths of an inch in diameter, and a still greater attenuation may be obtained by coating the wire with silver, drawing it out, and dissolving off the latter metal.

Platinum is very soft and flexible, and when rolled into thin sheets, say 28 or 30 of the gauge-plate, and well annealed at a strong white heat for eight or ten minutes, it may be readily forced into all the inequalities of a zinc die without producing any appreciable change in the face of the latter.

The following interesting and practical observations on the method of melting and welding platinum scraps, are taken from a recent dental publication,* by E. A. L. Roberts. By this process, the operator will be enabled to re-convert his waste scraps of platinum into convenient forms for use, and which he could not otherwise avail himself of on account of the infusible nature of this metal in its uncombined state.

* Dental Instructor, vol. i. p. 10.

"Platinum used by dentists should be soft, tough, and without flaws. These qualities can be attained only by thorough melting and welding. The welding must be done at a white heat. When the surface is cool enough to be visible, the metal is too cool to be welded, and every blow is injurious, because it has a tendency to shatter and shake it to pieces. The necessary delicacy of this process, and the uncertainty of success, has led some writers to declare that platinum is incapable of being welded. The platinum must be perfectly clean, and must be heated in a muffle. When welded, the metal should be handled with tongs plated with platinum, and hammered with a clean hammer on a clean anvil, both of which should be as hot as possible, without drawing the temper of the steel. The hammer used in welding should weigh about a pound, to prevent drawing the metal; but when welded, the metal may be forged with a heavier hammer.

"The scraps or sponge should be condensed in a square mold, very compactly, two pieces of which, weighing from ten to twenty ounces, may be put into a muffle together. When the heat becomes so great, that on opening the door the metal becomes invisible, bring one of the pieces in the tongs quickly to the anvil, give it three or four quick, sharp blows, in rapid succession. Return the piece to the muffle, and proceed with the other piece in like manner, and thus alternately till both are thoroughly welded.

"We use one of our improved tooth-furnaces of the largest size, fourteen by ten inches, inside measure.

"Platinum should never be thrown into water while hot, as that tends to make it crystallize. It should be thoroughly hammered, as it makes it tough and fibrous. The following process gives the best results in melting this metal. Condense the scraps, sponge or filings in an iron mold. Lay the condensed mass on a concave fire-brick, and heat it to whiteness. Take the brick from the muffle, and place it in a sheet-iron pan, coated with plaster and asbestos. The pan should

be deep enough and broad enough to catch all the globules and other loose particles of the metal. Place it under the jet of the oxy-hydrogen blowpipe, in the following manner:

"The pan is provided with a handle, opposite to which is a ring, which is to be attached to an iron hook and rod, suspended from the ceiling by a slip of India rubber, which enables the operator to hold the pan conveniently at any distance from the jet of the burning gases. The hydrogen is first lighted, and gives a powerful flame, but as the oxygen combines with it, the flame subsides into an intense focus of heat, in which the metal is soon brought to a state of fusion. Begin at one end and melt along toward the other, till the whole is fused in one mass. The platinum in this condition, when cool, is quite crystallized and sonorous. It breaks very easily, like spelter-zinc. Heat it very hot and forge it. A continuation of this process renders it soft, tough, and fibrous. When reduced to the width desired, and to the thickness of one-fourth of an inch, it should be made very hot, and passed instantly through the rollers."

Platinum, in mechanical practice, is chiefly employed as a base for continuous gum work; it is also used as a coloring ingredient of porcelain, and for pins in the manufacture of mineral teeth; and, to a limited extent, in some of the minor operations of the shop.

Pure gold is the only proper solder for this metal.

Alloys of Platinum.—Platinum unites with most of the base metals, forming alloys of variable degrees of hardness, elasticity, brittleness, color, fusibility, &c., but their practical value to the dentist is not sufficient to justify a separate description of their properties.

Alloyed with *gold* it forms a straw-colored alloy, the shade depending on the quantity of gold added. *Silver* hardens it, the resulting alloy being unaffected by sulphur.

Platinoid Metals.—The platinoid metals, palladium, iridium, osmium, rhodium, and ruthenium, are native contaminations,

the alloys of these metals having a close general resemblance to platinum.

Among the platinoid metals, palladium is the only one that has been used for dental purposes, and that only to a limited extent. It is of a steel-gray color, and when planished, is a brilliant steel-white metal not liable to tarnish in the air. Though closely resembling platinum, it may be readily distinguished from the latter metal by the following tests: 1. It has little more than one-half the density of platinum. 2. If a piece of it is heated to redness, it assumes a bronze-blue shade of greater or less intensity, as it is cooled more or less slowly; but if it is suddenly chilled by immersing it in cold water, it instantly resumes its original lustre. 3. When a drop of the tincture of iodine is let fall upon its surface and evaporated over the flame of a lamp, a black spot remains, which does not occur with platinum. Palladium melts at about 9500° Fah., and does not oxydize at a white heat. Its specific gravity is from 11·8 to 12·14.

CHAPTER VIII.

ALUMINIUM.

Aluminium is the metallic basis of alumina, the latter being the characteristic ingredient of common clay. It is only within the past few years that the attention of chemists has been directed to the production of this remarkable metal with a view to its general introduction into commerce and the arts. Prior to the researches of M. Deville, who, under the patronage of the present Emperor of the French, commenced his researches in 1854 for the production of this metal on a large scale, the small quantities produced and the corresponding exorbitant prices it commanded, rendered it entirely unavailable for other purposes than merely scientific experiment. The improvements in the method of obtaining it, however, which have been recently introduced, cannot fail, by rendering its production more economical, to supply it in much larger quantities and at a corresponding reduction in the cost of the metal.

The following account of the properties of this metal is taken from a paper read before the Society of Arts, London, by its Secretary, P. Le Neve Foster. It embodies the most authentic and complete description of the properties of aluminium that has yet been published.

"One of the most striking properties of aluminium is its extreme lightness, its specific gravity being 2·6, nearly that of glass, whilst that of platinum is 21·5, gold 19·5, silver 10·5, copper 8·96, zinc 7·2, tin 7·3.

"The metal is malleable, ductile, almost without limit; it can be reduced to very thin sheets, or drawn into very fine threads. Its tenacity, though superior to that of silver, is

less than that of copper; but no very accurate experiments have been made in this respect.

"When pure, it is about as hard as silver. Its elasticity is not great. It files readily, and is said not to injure the file. It conducts electricity with great facility, so that it may be considered as one of the best conductors known, almost equal in this respect to silver, and more than eight times a better conductor than iron. It melts at a temperature a little above that of zinc, between zinc and silver. In its chemical qualities it would seem to take an intermediate rank between what are termed the noble metals and the common metals, being, as Deville states, one of the most unalterable of metals.

"It might be imagined that it would as readily re-assume its oxygen as it parted with it with difficulty when in its state of oxyd. This, however, is not the case; it appears to be as indifferent to oxygen as either platinum or gold. In air and in oxygen it undergoes no sensible alteration, and it even resists it at the highest temperature which Deville could produce in a cupelling furnace, a temperature higher than that employed in assaying gold. Water has no action, according to Deville, on aluminium, neither at its ordinary temperature, nor when boiling, nor even upon the metal at a low red heat, near its melting point. According to Professor Crace Calvert, this statement must be received with some degree of caution, as in experiments he has made he considers that oxydation does take place slowly when the metal is immersed in water for any considerable length of time. It is not affected by sulphur or sulphuretted hydrogen, like silver, nor is acted upon to any considerable degree by any of the oxy-acids in the cold; nitric acid, whether strong or weak, at its ordinary temperature, in no way affects it, though when boiling it acts upon it slowly. Small grains of aluminium, plunged in sulphuric acid for three months, remained apparently unaltered. The vegetable acids, such as acetic, oxalic, and tartaric acids, have scarcely any effect on it at all. The

true solvent of the metal is hydrochloric acid, which attacks it rapidly. It appears to resemble tin when brought into contact with hydrochloric acid and the chlorides. Its absolute harmlessness permits of its being employed in a vast number of cases where the use of tin would not be desirable on account of the extreme facility with which that metal is dissolved in the organic acids.

"Figuier, in his scientific Year Book for 1858, just published, states that the caustic alkalies, potash, and soda, and even ammonia, dissolve aluminium sensibly. He also states that common salt and acetic acid, (vinegar,) especially when mixed, attack and dissolve aluminium. He adds, that the mixture of salt and vinegar for seasoning a salad, made in a spoon of aluminium, feebly but inevitably attacks it.

"All these points, however, deserve to be inquired into, as there seems some discrepancy between different writers on them."

Alloys.—"Aluminium, like iron, does not unite with mercury, and scarcely at all with lead. It, however, forms a variety of alloys with other metals. It can be alloyed with iron, and when aluminium becomes cheaper, it will be curious to see what effect mixtures of this metal with iron will have upon its quality, whether for good or for evil. It seems to unite readily with zinc, and these have been found to give the best promise as solders for aluminium; but, unfortunately, when melted, neither of them are sufficiently liquid, and does not run readily. The joints will not bear a blow. A variety of alloys with nickel have been made, and that consisting of 100 parts of aluminium and 3 of nickel, is found to work readily, and to have gained hardness and rigidity, as compared with the pure metal. The alloys, however, with copper are the most striking; they are light and very hard, and capable of a fine polish. In the same degree that copper adds to the hardness of aluminium, so does the latter, when used in small quantities, give hardness to copper, without, however, injuring its malleability. It renders it susceptible

of a fine polish, and, according as the proportions are varied, the color of the alloy becomes deep or pale gold. Alloys of copper with five and ten per cent. of aluminium, resemble gold perhaps more than any other metallic alloy hitherto employed. They do not tarnish sensibly by exposure to the air. Aluminium can be deposited by the battery, and by the same agent it can be gilt or silvered."

Some attempts have been made to render aluminium available as a base for atificial teeth, but with only partial success. When in the form of plate, no suitable solder has yet been discovered by which the several parts of a dental appliance may be securely united to each other; and experiments in casting this metal have practically failed, owing to its extreme lightness and consequent want of fluidity. More experience in its proper management, and a further acquaintance with its capabilities in yet unknown forms of combination with other metals, may ultimately demonstrate its applicability to dental purposes.*

* Some account of the more recent successes obtained in the use of aluminium for dental purposes will be found under the head of "Aluminium Base," to which the reader is referred.

CHAPTER IX.

COPPER, ZINC, LEAD, TIN, ANTIMONY, AND BISMUTH.

COPPER.

Copper is one of the metals most anciently known; is of a brownish-red color, with a tinge of yellow; has a faint but nauseous and disagreeable taste, and imparts, when exposed to friction, a smell somewhat similar to its taste. Its specific gravity ranges from 8·8 to 8·9. It is both malleable and and ductile, but excels in the former property, finer leaves being obtained from it than wire. It is inferior to iron in tenacity, but surpasses gold, silver and platinum in this respect. Copper melts at 1996° Fahrenheit.

Alloys of Copper.—Copper unites readily with most metals, forming alloys of great practical value in the arts, but which have but a limited application in dental laboratory processes. Many of these alloys are curious and instructive as illustrating the singular and unaccountable influence of alloying upon the distinctive properties of the component metals. Copper and tin, for example—the former of which is highly ductile, and the latter equally malleable—when combined in the proportion to form speculum metal, (9 C—1 T) forms an alloy distinguished for its extreme brittleness, with a surface hardness almost equal to steel. By increasing the quantity of tin until the compound assumes the proportions constituting gun metal, (C 2—T 1) the alloy, though neither malleable or ductile, becomes eminently tough and rigid. Other prominent examples might be given, showing how completely this combining influence defies all calculations in regard to ultimate results. The following summary em-

braces the names and composition of the more familiar alloys of copper, omitting, as unnecessary in this connection, a description of their individual properties.

Alloys of Copper with Zinc.—*Brass* is an alloy of uncertain and variable composition, consisting usually, however, of 2 to 5 parts of copper and one of zinc. Brass melts at 1869° Farh. *Prince's metal*, and its allied compounds, *Pinchbeck*, *Similor*, and *Manheim gold*, consists of nearly equal parts of copper and zinc. *Mosaic gold* consists of 100 parts of copper and from 52 to 55 of zinc. *Dutch gold*, from which foil of that name was formerly obtained, is formed of 11 parts of copper with 2 of zinc. *Bath metal* is composed of 32 parts of brass and 9 of zinc.

Brass solder consists of two parts of brass and one of zinc, to which a little tin is occasionally added.

Alloys of Copper with Tin.—*Bell metal* usually consits of 100 parts of copper with from 60 to 63 parts of tin. *Cannon metal* is compounded of 90 parts of copper with 10 of tin. *Cymbals* and *gongs* contain 100 parts of copper and 25 of tin. *Speculum metal* consists of 2 parts of copper and 1 of tin.

Copper and arsenic form a white-colored alloy, and in the proportion of 9 parts copper and one of arsenic, is white, slightly ductile, and is denser and more fusible than copper.

Genuine *German silver* is composed of copper 40·4; nickel 31·6; zinc 25·4; iron 2·6; but the proportions of the metals of this alloy differ according to the various uses to which this compound is applied.

Chinese packfong consists of 5 parts of copper alloyed with 7 parts of nickel and 7 parts of zinc.

A very useful alloy, employed in making plummer blocks, bushes, and steps for the steel and iron gudgeons and pivots of machinery to run in, is said to consist of 90 parts of copper, 5 of zinc, and 5 of antimony.

ZINC.

Zinc is a bluish-white metal, possessing considerable lustre when broken across. The commercial variety is always impure, containing traces of iron, lead, cadmium, arsenic, carbon, etc. It does not easily tarnish in dry air, but soon becomes dull on exposure to moisture. In the condition in which it ordinarily occurs it is a brittle metal, but may be rendered malleable by annealing it at certain temperatures. This change in its condition is effected by subjecting it to a heat of from 220° to 300°, at which temperature it may be rolled into sheets, and retain its malleability when cold. The best annealing temperature for zinc is about 245°. A knowledge of this fact will enable the operator to avail himself of the advantages of this property by annealing his zinc die, by which its liability to crack or part under the hammer is diminished.

The specific gravity of zinc varies from 6·9 to 7·2. It melts at about 773°, and when heated much above this point with contact of air, it burns with a brilliant greenish-white flame, while woolly-looking flocculi rise from the vessel in which it is being heated and float in the air.

Zinc has been long and almost exclusively employed in the formation of dies used in swaging metallic plates employed in mounting artificial teeth, and experience has very justly accorded to it undisputed pre-eminence above all other unalloyed metals for the purpose. A more particular account of its peculiar fitness for dental purposes will be given under the head of Metallic Dies and Counter-Dies.

LEAD.

Lead has a grayish-blue color, with a bright metallic lustre when melted or newly cut, but it soon becomes tarnished and dull-colored when exposed to the air. The specific gravity of commercial lead, which is usually contaminated

with other metals, is 11·352. It fuses at 612°. Exposed to a high heat, it absorbs oxygen rapidly, forming on its surface a gray film of protoxide and metallic lead. It is both malleable and ductile, but soft and perfectly inelastic.

Lead, either in its pure state or when alloyed with certain other metals, serves important purposes in the laboratory. In its simple or uncombined state it is useful only in forming counter-dies. Alloyed with antimony in the proportion of from $\frac{1}{4}$ to $\frac{1}{8}$ of the latter, with the addition sometimes of very small portions of copper, tin, and bismuth, it forms different grades of *type metal*, which is harder than lead, and very brittle, and is sometimes used for dies; and sometimes, though very rarely, for counter-dies. When used as a counter to a zinc die, it is improved for the purpose by adding to it an equal quantity of lead; it may also be used in the form of a die in connection with a lead counter after rough stamping with zinc.

The alloy known as Rose's *fusible metal* is composed of 2 parts of bismuth, 1 of lead, and 1 of tin, and melts at about 200°. A still more fusible alloy is composed of lead 3 parts, tin 2 parts, and bismuth 5 parts, which fuses at 197°. There are other alloys of lead, to be mentioned hereafter, melting at from 200° to 440°, which may be advantageously employed in forming dies to be used after zinc, where the latter, from its greater shrinkage, fails to bring the plate into accurate adaptation to the mouth.

Soft solder is an alloy composed of lead and tin in the proportion of two parts of the former with one of the latter.

TIN.

Tin is a brilliant, silver-white metal, the lustre of which is not sensibly affected by exposure to the air, but is easily oxydized by heat. It has a slightly disagreeable taste, and emits, when rubbed, a peculiar odor. It is soft, inelastic, and, when bent, emits a peculiar crackling sound called the

creaking of tin. It is inferior in tenacity and ductility, but is very malleable, and may be beaten into leaves the $\frac{1}{2000}$ of an inch in thickness; ordinary *tin foil* being about $\frac{1}{1000}$ of an inch thick. It fuses at 442°; boils at a white heat, and burns with a blue flame to binoxide.

The more common alloys of tin with other metals have already been noticed. It was at one time used as a base for artificial teeth; and, more recently, it has been introduced as a component of "cheoplastic" metal, a compound used for the same purpose. In its pure state, it is sometimes used for counter-dies, and occasionally for dies. When employed for the latter purpose in connection with a lead counter, the latter should not be obtained directly from the die, as the high temperature of melted lead would produce, when poured upon tin, partial fusion of the latter and consequent adhesion of the two pieces. When tin is used in the formation of a die, therefore, either a counter previously obtained from a zinc die should be used, or the "dipping" method employed, by which the counter-die is first obtained from the plaster model, and a die from the counter.

ANTIMONY.

Antimony is of a silver-white color, with a tinge of blue, a lamellar texture, and crystalline fracture. It is brittle and easily pulverized. The specific gravity of the purest variety is 6·715. It fuses at about 810°, and when heated at the blowpipe, it melts with great readiness, and diffuses white vapors, possessing somewhat of a garlic smell.

Antimony enters as an ingredient into the composition of type and stereotype metal, music plates, and Britannia metal. It is also a component of certain fusible alloys analogous to those already mentioned under the head of lead, and which, in the form of a die, are sometimes used on account of their slight degree of shrinkage.

BISMUTH.

Bismuth is a white-colored metal resembling, in some degree, antimony. It is soft, but so brittle as to be easily pulverized. Its specific gravity is 9·83, which may be increased somewhat by hammering. It melts at 480° Fah., and may be cooled six or seven degrees below this point without fixing; but the moment it begins to solidify, the temperature rises to 480°, and continues stationary till the whole mass is congealed. When the temperature of the metal is raised from 32° to 212°, it expands $\frac{1}{720}$ in length.

Bismuth has the property, in a high degree, of increasing the fusibility of the metals with which it is incorporated, and is a common ingredient of the more fusible alloys, some of which melt in boiling water. One part of bismuth with 24 of tin is malleable, but the alloy of these metals becomes brittle by the addition of more bismuth. Bismuth unites readily with antimony, and in the proportion of one part or more of the former to two of the latter, it expands in the act of cooling.

There are many other metals and alloys besides those already enumerated, but which have not been particularly described on account of their inutility in the laboratory for dental purposes. Among these may be mentioned, *iron, brass, bronze, &c.*, which are only employed for auxiliary purposes, and are both inconvenient and impracticable for dies on account of their infusible nature and consequent contraction; *nickel*, on account, also, of its extreme infusibility and its tendency to render the alloy, of which it is a component, less fusible; *sodium*, on account of the changes produced on it by exposure to the air; *potassium*, on account of its extreme sensitiveness to the influence of low temperatures, being semi-fluid at 60° Fah., nearly liquid at 92°, and entirely so at 120°; *arsenic*, because it volatilizes before fusing: *cadmium*, with no advantages above tin, on account of its scarcity and costliness, &c.

CHAPTER X.

GENERAL PROPERTIES OF ALLOYS, AND THEIR TREATMENT AND BEHAVIOR IN THE PROCESS OF COMPOUNDING.

All alloys possess metallic lustre; are opaque, conduct heat and electricity; and, in a greater or less degree, are ductile, malleable, elastic, and sonorous. Some alloys, as brass, and gong-metal, are usually malleable in the cold, and brittle when hot.

Metals sometimes unite in atomic ratios, forming compounds of definite or equivalent proportions of the component metals; as certain alloys of copper and zinc; gold and copper; gold and silver; mercurial alloys, &c.; while, on the other hand, many are formed in all proportions, like mixtures of salt and water.

Metals differ in respect to their affinity for each other, and do not, therefore, alloy with equal facility; thus it is difficult to unite silver and iron, but the former combines readily with gold, copper, or lead.

The ductility of an alloy is, in general, less than that of its constituent metals, and this difference is, in some instances, remarkably prominent, as in the case of certain alloys of copper and tin already mentioned.

An alloy is generally harder than the mean hardness of its components, a property which, when taken in connection with their increased fusibility, gives to alloys peculiar value in the formation of dies for stamping purposes. To the rule stated, amalgams or mercurial alloys are cited as exceptions.

The density of an alloy varies with the particular metals composing it; being generally either greater or less than the mean density of its several components.

It is impossible to predict with certainty the melting point of an alloy from that of its separate constituents, but, generally, the fusibility of the alloy is increased,—sometimes in a most remarkable degree. The alloy of 5 parts of bismuth, 3 of lead, and 2 of tin, is a striking example of this fact; this compound, melting at 197°, while the mean melting point of its constituents is 514°. Silver solder is also a familiar illustration of the influence of alloying on the fusibility of metals; copper melting at 1996°, and silver at 1873°, when combined, fuse at a heat much below that required to melt silver, the more fusible component of the alloy. Again, iron, which melts at a little less than 3000°, acquires almost the fusibility of gold when alloyed with the latter. Examples might be multiplied, but it will be sufficient to add, that, in general, metallic alloys melt at a lower heat than is required to fuse the most refractory or infusible component, and sometimes than the most fusible ingredient.

The color of an alloy cannot, in general, be inferred from that of it component metals; thus, it would be conjectured that copper would be rendered very much paler by adding to it zinc in considerable quantities; but the fallacy of such an inference is at once shown by an examination of some of the rich-looking gold-colored varieties of brass, as Prince's metal, pinchbeck, and similor, composed each of nearly equal parts of copper and zinc; and manheim gold, compounded of 3 parts copper and 1 of zinc.

The affinity of an alloy for oxygen is greater than that of the separate metals; a phenomenon that is ascribed by Ure to the increase of affinity for oxygen which results from the tendency of one of the oxyds to combine with the other; by others, it is attributed to galvanic action. According to Faraday, 100 parts of steel, alloyed with one of platinum, is dissolved with effervescence, in dilute sulphuric acid too weak to act with perceptible energy on common steel. It is offered in explanation of this fact, that the steel is rendered positive by the presence of platinum. A similar illustration is

afforded by the action of dilute acid on commercial zinc, which is usually an alloy of zinc with other metals.

The action of air is, in general, less on alloys than on the separate metals composing them. To this, however, there are exceptions, as the alloy of 3 parts of lead and 1 of tin, which, when heated to redness, burns briskly into a red oxyd.

Some points of practical interest suggest themselves in connection with the behavior and proper management of alloys in the process of compounding.

As metallic alloys can only be formed by fusion, and as the affinity of the metals composing them for oxygen is greatly increased by heat, especially those denominated base, it is important that this tendency, which is incompatible with the proportional accurateness of the compound, should be, as far as practicable, guarded against. Hence, various substances having a greater affinity for oxygen than the metals to be united, as oil or grease, rosin, powdered charcoal, etc., are generally added, coating the surface of the liquid metals, and which by affording a protective covering, preserves, with little change, the proportions of the alloy.

Some difficulty is occasionally experienced in obtaining a perfectly uniform alloy, on account of the different specific gravities of the metals composing it—each metal assuming the level due to its density. This partial separation is common to gold and silver, provided they have not been adequately stirred before pouring. This result is not so likely to occur when the metals employed are in small quantities, and are suddenly cooled; but when used in considerable masses, and allowed to cool slowly, it is much favored by permitting the metals to fix themselves in the order of their separate densities. Hence, whenever a notable difference in the specific gravity of the metals exists, the fused mass should be briskly stirred immediately before the instant of pouring it, and should be made to solidify quickly. If uniformity be not obtained in this manner, it will be necessary to re-melt

and repeat the process, if necessary, until the alloy is rendered sufficiently homogeneous.

In alloying three or more metals differing greatly in fusibility, or that have but little affinity for each other, it is better to first unite those which most readily combine, and afterward, these with the remaining metal or metals. If, for example, it is desired to unite a small quantity of lead with brass or bronze, some difficulty would be experienced in forming the alloy by direct incorporation of the metals; but union could be readily effected by first melting the lead with zinc or tin, and then adding the melted copper.

PART SECOND.

ARTIFICIAL DENTURES.

Before considering particularly the distinct and special methods employed in the construction of artificial dentures, such preliminary processes as are common in some degree to all, will, for the sake of convenient arrangement, and the avoidance of unnecessary repetition hereafter, be first considered. These processes relate, 1. To the treatment of the mouth preparatory to the insertion of artificial teeth. 2. The manner of obtaining impressions of the mouth. 3. The manner of procuring and forming plaster models of the mouth. 4. Metallic dies and counter-dies.

CHAPTER I.

TREATMENT OF THE MOUTH PREPARATORY TO THE INSERTION OF ARTIFICIAL DENTURES.

It rarely occurs that all the structures of the mouth are in such condition as will render it proper to insert an artificial appliance without some preparatory treatment. This important requirement cannot, in any material respect, be disregarded by the practitioner without endangering the utility and permanence of the substitute, and inflicting upon the patient a train of consequences alike distressing and pernicious. Every experienced dentist is familiar with the fact, that an artificial substitute resting upon diseased roots of teeth, and impinging continually upon gums already irritable and inflamed, soon becomes a source not only of annoyance

and discomfort to the patient, but is rendered, in a great degree, inefficient in the performance of some of its more important offices. There is, besides, a perpetual and cumulative aggravation of the morbid conditions, and sooner or later irretrievable destruction of the remaining natural organs will be induced. These consequences cannot be wholly averted by the most skillful manipulation, but they may be greatly magnified by a defective execution of the work, or by a faulty adaptation of the appliance to the parts in the mouth.

Patients not unfrequently attempt, by every artifice or pretext that caprice or timidity may suggest, to persuade the operator to violate his own clear convictions of duty, but, unless under circumstances of peculiar exigency, he should be careful to guard himself against the imputation of incompetency or bad faith by being peremptory and unyielding in his demands upon the patient to submit to the necessities and just requirements of the case, and no ordinary circumstance should influence him in opposition to his better informed judgment.

The conditions, usually met with, to which it will be necessary to direct attention in the treatment of the mouth, are, the presence of useless and diseased remains of teeth; accumulations of tartar; diseased states of the gums and mucous membrane; and caries.

Useless and Diseased Remains of Teeth.—It may be stated, as a general rule of practice, that all the remaining natural teeth that are not susceptible of being restored to a state of comparative health and usefulness, should be removed before inserting an artificial substitute. Especially should this course be pursued whenever the remaining roots are found partially or wholly necrosed, and the peridental membranes and surrounding tissues inflamed and suppurating. Such should be extracted if for no other reason than that they are offensive in the mouth, and tend, in a greater or less degree, to compromise the general health.

In respect to the utility, comfort, and permanence of a

dental appliance, the expediency of removing the roots of teeth prior to the introduction of the former, is apparent. If a dental substitute is adapted with necessary accuracy to all the parts which it covers, it will be plainly seen that the forces applied to the base at every occlusion of the jaws in the act of mastication, instead of being equalized or diffused, will be expended mainly on the fangs, inasmuch as they afford so many fixed points of resistance, whilst the adjacent soft tissues, yielding to the pressure, permit the artificial piece to bear with undue and unequal force upon the roots. The consequences of this action are inevitably pernicious. In a comparatively short time, inflammation and suppuration are induced about the fangs, which ultimately become loosened and painfully sensitive to the slightest pressure; the secretions of the mouth, becoming more and more acrimonious, act persistently and with increasing energy on oxydable materials present in the mouth, as well as upon the remaining natural teeth, inducing rapid and general decay; contiguous parts, through their immediate connection or sympathetic relations with the structures of the mouth, respond to the local disturbances, and the case, in time, becomes complicated with those various distressing maladies about the head and face so commonly associated with diseased conditions of the buccal cavity. At last, the patient, no longer able to endure the offensiveness and distress arising from the presence of the substitute in the mouth, or to properly masticate his food, is compelled to have the offending organs removed. The absorption of the gums and processes which follow this operation, and the corresponding changes which occur therefrom in the form of the alveolar ridge, make it imperative in all cases either to reconstruct the same piece or to supply the patient with an entirely new substitute; whereas, if due regard is had to the proper preparation of the mouth in the first instance, the patient may be spared such inflictions, and the operator the discredit which almost invariably attaches to the neglect of the measures recommended.

An additional reason why roots of teeth should be extracted is, that their presence prevents, in some degree, an accurate and uniform adaptation of the appliance to all the parts on which it is designed to rest, and this is particularly true of those cases where atmospheric pressure is made available in the retention of the substitute. Any condition of the mouth that prominently modifies the natural and uniform pliancy of the soft parts will, just to that extent, weaken the attachment of the plate. This fact is made obvious when we reflect that it is only the soft and yielding condition of the mucous membrane and gums that permits the adhesion of the artificial appliance for a single moment by atmospheric pressure; for it will be readily comprehended that, if the tissues on which it rests were as hard and unyielding as bone, a dental substitute, though it were moulded directly to the parts, would not be sustained for an instant by the external pressure of the air.

The retention of every root that may, by treatment or otherwise, be secured in good condition, has been insisted on by a few in the profession, on the ground that they afford a fixed and permanent basis for the dental appliance, and preserve, without change, the customary fullness and contour of the mouth. Individual instances doubtless occur that render this course admissible, but as a rule of practice, it is exposed, though in a less degree perhaps, to the same objections which have been adverted to in connection with diseased roots. However carefully or skillfully such roots may be treated and prepared, or the substitute applied, entire success and permanent benefit to the patient cannot be reasonably anticipated. It rarely happens that the fangs of teeth, whose crowns have been destroyed by caries or accident, are found without having suffered, at some time and in some degree, from disease of the investing membranes and surrounding structures, and although these conditions may have apparently subsided, or may have been temporarily subdued by treatment, yet observation of such cases leads to

the conclusion that, however free from indications of active disease there may appear at the time, the latent predisposition favoring a recurrence of the morbid action usually exists in such cases, and it will require no greater provocation than the continued and unequal action of an artificial fixture on them to awaken this predisposition into active development.

From the views here expressed, we are convinced that, as a principle of practice, the fangs of teeth, however apparently free from disease, should be extracted in the first instance. There are, nevertheless, circumstances which clearly justify a departure from the rule we have endeavored to enforce; as in the process of engrafting an artificial crown upon a well-conditioned root; or supplying the loss of one or more of the front teeth by attaching the artificial organs to a plate and fixing the latter in the mouth by pivoting to one or more of the natural roots. Either of these methods may, under certain circumstances and within certain limitations, be preferable to extracting the roots of such teeth and supplying the vacuities by other means.

Removal of Salivary Calculus or Tartar.—The deposits of tartar which so frequently collect at the necks of the teeth and under the free margins of the gum, not only promote inflammation and absorption of the investing membrane and contiguous soft parts, but involve, by degrees, the alveolar processes in the destructive action; so that teeth originally firm become loosened in their sockets, and thus, in their turn, become additional sources of diseased action in the surrounding structures. Hence it becomes absolutely necessary, as it relates to the general health of the mouth, to thoroughly remove, with suitable instruments, all traces of this concretion from the teeth.

If any considerable number of the teeth are found coated with tartar, and it is deposited in large quantities, it will be impracticable, as a general thing, to remove thoroughly all remains of it at a single sitting. The operation should be repeated, therefore, from time to time, until every portion of

it is completely separated from the teeth; the latter should then be well polished with suitably shaped burnishers, and the gums, if highly inflamed and turgid, may be either freely scarified at those points where they dip between the teeth, or cleansed and treated with appropriate detergent and remedial agents.

Diseased Conditions of the Mucous Membrane and Gums.—It will seldom be necessary to institute treatment for the reduction of inflammation and ulceration of the soft tissues of the mouth after the removal of diseased fangs and tartar, inasmuch as these conditions being generally provoked by, and associated with, the latter, will spontaneously subside with the removal of the exciting causes. If, however, there are other morbid conditions of the soft tissues, or osseous structures of the mouth not immediately arising from the presence of diseased roots and tartar, they should be treated in accordance with the particular pathological conditions present.

Caries or Decay of the Remaining Teeth.—In order that all the teeth which it is deemed advisable to retain in the mouth may be permanently preserved, it will be necessary to fill, or otherwise treat, such as may be affected by caries. This operation will be attended with more satisfactory results and be accompanied with less pain to the patient, and diminished risk of failure, when performed after the removal of the roots of teeth and tartar, and the restoration of diseased conditions of the mouth to health, as, in this case, there will be less irritability of the general system, and reduced sensitiveness of the teeth operated on.

Surgical Treatment of the Mouth after the Extraction of Teeth.—In the preparation of the mouth for entire sets of artificial teeth, it frequently becomes necessary to extract the remains of all or nearly all of the teeth of one or both jaws. In such cases, the ridge is left ragged and broken, with flaps of gum lying in loose folds along the border, and the exposed margins of the alveolar processes projecting from

underneath. These parts, if left in this condition, will be productive of more or less inconvenience to the patient; for as the gums close over and contract upon the cutting edges of the processes, irritation and inflammation will be induced at those points where they are most prominent. Immediately after the extraction of the teeth, therefore, any flaps of gum hanging loosely around the sockets should be clipped off, and sharp and protruding portions of processes cut away with excising forceps. If, in the course of a few weeks, prominences still remain, over which the mucous membrane is stretched and irritated or inflamed, as is more frequently the case around the sockets of the cuspidati, the membrane should be divided over such points with a lancet, and the sharp points of bone underneath broken down with suitable cutting instruments.

Time Necessary to Elapse, after the Extraction of Teeth, before Inserting Artificial Dentures.—The time that should elapse after extracting the natural teeth, before replacing them with artificial substitutes, will depend upon various circumstances. If the appliance is only intended to meet the wants of the individual until all the changes effected by absorption of the gums and processes are fully completed, it may be inserted in from one to three weeks, depending somewhat upon the number of teeth extracted, the extent of the injuries unavoidably inflicted upon the parts, and the virulence of the diseased action present in the structures of the mouth at the time of the operation. If there are no unusual complications, and the space or spaces to be supplied are such as are made by the loss of only one or two teeth at intervals, the parts quickly assume their normal condition, and the piece to be temporarily worn may be applied within a few days. If, however, a greater number or all of the teth have been removed, more or less inflammation and tenderness will be present for from ten days to two or three weeks, and which will render the wearing of an artificial piece uncomfortable to the patient, and in some degree mischievous, by aggravating the morbid condi-

tions already existing. Another objection to the too early introduction of artificial substitutes into the mouth arises from the fact that the changes which occur in the ridge are much more rapid within the first few weeks after the extraction of the teeth than at any subsequent period, so that the plate, if inserted immediately or within a few days after such operation, will soon lose its bearing upon the ridge and become inefficient for masticating purposes, or may even fail to be retained in the mouth without much annoyance to the patient. Two or more weeks, therefore, should elapse before applying the substitute. In the meantime, the patient should be seen frequently, and such medical or surgical treatment adopted from time to time as the case may demand.

It has been objected to the insertion of what are termed temporary sets of teeth, that they tend to produce unequal absorption of the parts on which they rest. We cannot but regard this view as mainly speculative. In respect to the upper jaw, at least, there is no such pressure exerted as would result in permanent irregularities in the ridge, for, as the latter recedes in the process of absorption, it is more and more relieved from direct contact with the plate covering it—that portion of the plate resting against the roof of the mouth preventing it from following the retreating gums. Hence it is that such substitutes soon begin to "rock" in the mouth, and are easily dislodged, when pressed upon laterally, in consequence of the want of an adequate marginal bearing. Nor does the objection hold good in reference to the inferior maxilla where the pressure of the substitute upon the ridge is continuous throughout the period of absorption; for if the ultimate form of the ridge were influenced at all in these cases, we should have, at the conclusion of the period, the same irregularities as at first, with simple diminution of substance; for we know of no peculiarities in the physiological condition of the structures that would render one part amenable to this assumed consequence of pressure and another exempt from it. Common observation, on the contrary,

clearly shows that the process of absorption and deposition go on, uninterruptedly, and are, in no appreciable degree, influenced by the presence of the temporary substitute in the mouth.

The advantages of temporary sets of teeth to the patient, on the other hand, are unquestionable. They fulfill, in a tolerable degree, all the requirements of artificial teeth under any circumstances, if we except that of mastication, this function being, more or less, imperfectly performed with such pieces. One of their most important offices consists in maintaining unchanged the customary relation or closure of the jaws. Undue projection, and in many cases, partial luxation, of the inferior jaw results from the loss of all of the teeth, and these conditions may become permanent in their character if long continued.

The time occupied in the *completion* of those changes which occur in the alveolar border after the extraction of all or any considerable number of the teeth, cannot be definitely stated, but will range from five to eighteen months or more, according to the amount of superfluous structures to be removed, the density of the osseous tissues, and the functional activity of the absorbents. In all cases, ample time should be permitted to elapse in order that no appreciable change in the form of the parts may take place after the appliance has been permanently adjusted.

CHAPTER II.

MATERIALS AND METHODS EMPLOYED IN OBTAINING IMPRESSIONS OF THE MOUTH.

In the process of constructing a dental substitute, it is of the first importance that as accurate an impression as possible should be obtained of all those parts of the mouth with which the appliance is in any way connected. If this important preliminary step is, in any essential respect, imperfectly performed, the ultimate utility of the artificial fixture will either be greatly impaired or wholly destroyed, notwithstanding all the subsequent manipulations may be most carefully and skillfully performed. The operator, therefore, should avail himself of every appliance and facility that will enable him to attain, in this respect, the most perfect results.

The materials ordinarily employed for this purpose are, wax, gutta percha, and plaster of Paris.

Wax.—There are two varieties of this substance in common use,—the *yellow* and *white* wax. The yellow variety is esteemed preferable to the white on account of its superior toughness; the latter being, to some extent, disintegrated, or rendered less tenacious in the process of bleaching, but is frequently used and is preferred by many on account of its color. The more desirable properties of the yellow wax are often impaired by the admixture with it of tallow, with which it is, for mercenary purposes, frequently contaminated. The presence of tallow may be detected by its characteristic odor, and by the whitish or pale yellow color it imparts to the wax, which in its pure state, is of a deep, bright straw color.

Wax used for impressions should always be kept in con-

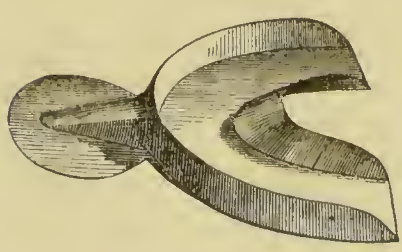
venient form for immediate use, and may be prepared either by warming it until sufficiently soft and then rolling or pressing it into thin sheets; or having melted it in a properly formed vessel, immerse in it a thin strip of board, previously moistened, and withdraw quickly; this is repeated as the successive layers cool, until a coating of sufficient thickness is obtained. The latter is a convenient method of obtaining sheets of wax of a uniform thickness, a form frequently required for various purposes in the dental laboratory.

Manner of Obtaining an Impression of the Mouth in Wax for Partial Upper Dentures.—Until within the past few years, wax has been used almost exclusively for the purpose of obtaining an impression of the mouth in those cases where any number of the natural teeth remain in either or both jaws, and, for this purpose, is ordinarily more convenient and manageable than plaster, and, if carefully manipulated, will secure in most cases a sufficiently accurate impression of the parts.

Before preparing the wax, a suitable cup or holder should be selected for the particular case in hand. These appliances are usually constructed either of plate or block tin, Britannia metal, or silver, and a sufficient number of the various forms required should be provided to meet perfectly every requirement in respect to the size and form of the jaws of individual cases.

For upper partial or broken sets, the form of cup represented in Fig. 19 may be used. It should be large enough to embrace the alveolar ridge, leaving a space of nearly a fourth of an inch between its outer rim and the external border of the gum. If it is designed to employ an atmospheric pressure plate covering nearly or quite all of the hard palate, a cup of the same general form, but with its central portion extended posteri-

FIG. 19.



orly, may be used; or a full cup like that represented in Fig. 21 may be employed. Having selected a cup of the proper form and size, the wax should be warmed in a spirit flame until it acquires about the consistence of freshly made putty. Wax is sometimes softened by immersing it in hot water, but the dry heat is preferable, as the former seems to impair, to some extent, its toughness and continuity. In taking the impression, the operator should place himself behind and to the right of the patient, and should be sufficiently raised above the latter to enable him to manipulate with the greatest ease and certainty, and at the same time, to command as full and unobstructed a view of the interior of the mouth as possible. The cup, with the wax arranged, should then be introduced into the mouth without unnecessary delay. To do this properly and without subjecting the patient to annoyance, will occasionally require some care and expertness on account of the disproportionate size of the cup and orifice of the mouth. An ample and expanded jaw, for example, is frequently associated with a small mouth, and if in addition to this the sphincter muscle of the mouth happens to be rigid and unyielding, the introduction of a cup of sufficient size may be attended with some little difficulty and embarrassment. This impediment, however, may be readily overcome in most cases by presenting the cup obliquely to the mouth, one side resting against, and pressing outward, the corner of the mouth, while, as the opposite corner is extended with the first and second fingers of the left hand, the cup is passed in with a rotary movement.

When the cup is within the mouth, it should be carefully adjusted over the ridge before pressing it up, so that no portions of the rim may cut into the soft tissues of the mouth, an accident liable to happen without care, and which will make it necessary in most cases to withdraw the cup before the impression is complete. The proper position of the cup in the mouth secured, it should be held firmly with the thumb resting on the handle above, and two or more of

the fingers on the under surface, when it is slowly but steadily and forcibly pressed against the parts above until the ridge is completely imbedded, and the wax carried closely against the roof of the mouth. The cup should then be held stationary with one hand while with the fingers of the other the wax around the margins of the cup should be pressed closely into all the depressions occurring on the outside of the ridge between the remaining teeth, or wherever irregularities may present themselves on the external border of the jaw. The finger should also be passed to the roof of the mouth at the central and posterior edge of the cup, making pressure against the protruding wax upward and forward into the anterior and deeper portions of the palatal arch. When the operation has been conducted thus far, and before removing the cup, gentle upward pressure upon the latter may again be made,—not enough to move the entire body of wax, but only sufficient to correct any partial displacement that may have happened from accidental tilting or lateral movement of the cup during the concluding manipulations.

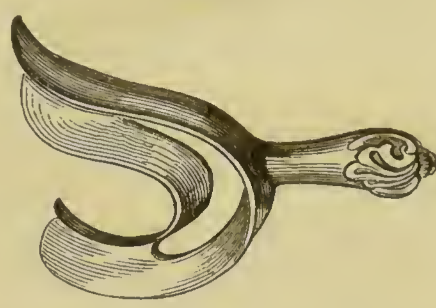
After the wax has remained in the mouth long enough to become in some degree hardened, it should be carefully detached by gentle traction upon the cup, and removed from the mouth in the same manner in which it was introduced; care being taken not to displace the wax or otherwise mar the impression. More or less dragging of the wax, however, will unavoidably occur in proportion as the teeth are irregularly arranged in the arch, or have contracted necks. Imperfections occurring from these sources may be remedied with tolerable accuracy by subsequent carving of the plaster model, but the better plan, where these conditions prevail to any considerable extent, is to substitute gutta percha for wax, the elasticity of this substance enabling it to regain the form it acquires in the mouth after having been temporarily disturbed or changed in the act of detaching it from the teeth.

Inasmuch as it is necessary, in constructing partial sets of

teeth, to be provided with two or more plaster models, and as the latter cannot well be obtained in perfect condition from a single impression, it is better that at least two of the latter should be secured in the first instance.

Manner of Obtaining an Impression of the Lower Jaw in Wax for Partial Dentures.—If the case is one where teeth at intervals are to be supplied, the form of cup used in taking an impression for an entire lower denture (Fig. 23) may be employed; or if the vacuity exists in the front part of the ridge only, then one like that represented in Fig. 19 will answer the purpose. If, however, as is more generally the case, the front teeth remain, and those posterior to the cuspids or bicuspids are to be replaced, the form of cup exhibited in Fig. 20 should be used; a portion being cut out from the front part of it, forming a vacuity which receives and permits an unobstructed passage of the front teeth. As the latter are often very long, it is difficult, with the ordinary form of cup, to press the wax down fairly upon the ridge behind without bringing their cutting edges prematurely in contact with the floor of the cup in front. Instead of the opening represented in the cup, however, it will be sufficient in most cases to have it formed with a depression in front of adequate depth to receive the points of the anterior teeth.

Fig. 20.

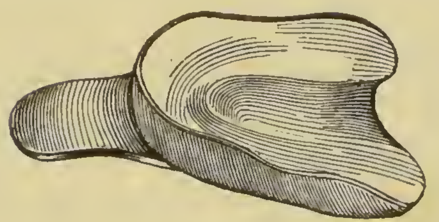


In taking an impression of the lower jaw, after having prepared and arranged the wax by softening and filling the groove of the cup flush with the margins, the operator may first take a position to the right and back of the patient, and introduce the cup into the mouth in the manner heretofore described, when he should pass to the front of the patient, and having adjusted the cup properly over the ridge, the first two or three fingers of each hand should be placed upon

the top of each side of the cup, and a thumb upon each side and underneath the jaw, and firm and steady pressure made until the ridge is wholly imbedded. The wax may then be pressed in around the margins of the cup, and the impression carefully removed from the mouth in the manner before indicated.

Manner of Obtaining an Impression of the Mouth in Wax for Entire Upper Dentures.—The form of cup employed in taking an impression of the upper jaw in the absence of all the natural teeth, is seen in Fig. 21. A number of these corresponding as nearly as possible in form and size to the various modifications in the configuration and dimensions of the maxillary arch, should be kept conveniently at hand. If the teeth have been recently extracted, the wax should be prepared somewhat softer than usual to prevent displacement of the gums, which, in their unabsorbed condition, possess more or less mobility. The cup should be filled flush with the edges, and built up in the centre if the depth of the palatal vault requires it, and the wax properly trimmed; it is then introduced into the mouth and adjusted to the ridge, as already described, and pressed to the jaw with sufficient force to fully encase all the parts to which the substitute is ultimately to be applied. The wax, as the cup is pressed up, has a tendency to roll out at its edges and thus depart from the upper and outer portions of the ridge; hence care must be taken to press the wax in around the marginal portions of the cup, filling up any depressions or fosses that may occur on the external border of the jaw. It is particularly necessary to observe this precaution whenever the ridge overhangs, as is prominently the case for the first few months after the extraction of the teeth.

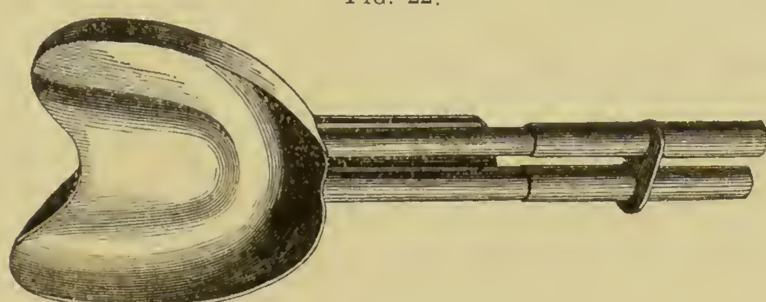
Fig. 21.



If the impression is an accurate one, some difficulty is oc-

casionally experienced in detaching it from the mouth on account of the thorough exclusion of air from between it and the mouth, the wax being held firmly in place by atmospheric pressure; in which event it is only necessary to admit the air between the two, and this may generally be readily effected by placing the finger against the jaw on one side and above the wax, pressing firmly toward the centre of the arch and upward, dragging the mucous membrane somewhat from the edge of the cup, and at the same time depressing the latter on the same side. A small portion of air being admitted, it will soon diffuse itself between the adhering surfaces and allow the wax to be readily detached. To harden the wax, and thereby prevent it from dragging at those points where the ridge overhangs, or to prevent any change of form on the application of sufficient force to detach it from the mouth when it adheres with great tenacity, a cup has been constructed with a chamber underneath into which a stream of cold water is admitted. Two short pipes, as will be seen by reference to Fig. 22, communicate with the chamber, and these again connect with a double tube fitting them closely, and united at the other end, with two gum elastic tubes—one communicating with a vessel of water conveniently placed and provided with a stop-cock, the other leading to a spittoon or other waste place. The two portions of pipe may be disconnected when not in use. After taking an impression with this cup, and before removing the wax from the mouth, the two portions of pipe are connected and a con-

Fig. 22.



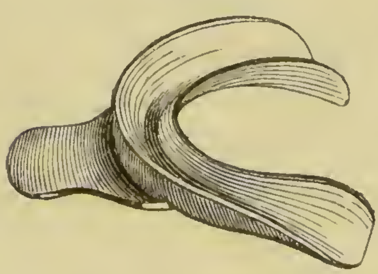
tinuous current of cold water passed through the chamber by turning the faucet connected with the tank; when sufficiently hard, the wax is removed from the mouth before disjointing the pipes to prevent the water from flowing upon the patient.

To provide more perfectly against failure of the wax being carried closely against the roof of the mouth in cases where the palatal vault is very deep, a piece may be cut from the central part of the cup, the wax being pressed at this point upward and forward into the deeper portions of the palatal fosse.

The author would express, in this connection, his conviction that it is impracticable, in most cases, to obtain a faultless impression of the mouth in wax for full upper dentures. There are points, not readily accessible to the fingers, where the wax departs from the external and posterior borders of the jaw, and is not, therefore, susceptible of easy correction; besides, when reached and the remedy applied, there is no certain assurance that in pressing the wax in at one point we are not displacing it at another. For this reason, we invariably use plaster in these cases, and we have sufficient reason to believe that the results are more uniformly successful.

Manner of Obtaining an Impression of the Lower Jaw in Wax for Entire Dentures.—The method pursued in securing an impression of the lower jaw in wax for an entire denture, differs in no essential respect from that described when taking an impression for lower partial pieces, the form of cup being represented in Fig. 23. When the parts are imbedded in the wax, the latter should be pressed in around the inner border of the holder, but more especially near the posterior part of the ridge on each side where the latter overhang and ap-

Fig. 23.



proximate each other, forming corresponding excavations underneath. After adjusting the wax to the ridge along the border of the cup, the latter should again be pressed directly down upon the jaw before removing it, to correct any partial deformity that may have occurred during the previous manipulations.

Gutta Percha.—This material is rarely used except in obtaining impressions for partial pieces, and is more particularly indispensable whenever a perfect representation of the parts in plaster is essential to the success of any method in which the base is moulded or cast upon the model, as in the case of the "Vulcanite" or "Cheoplastic" processes. It takes the form and position of the teeth readily, and preserves them unchanged, by virtue of its elasticity, when removed from the mouth.

The general management of this substance in the process of obtaining an impression with it, is in most respects, similar to that of wax, when used for the same purpose. It should, however, be prepared by softening it in hot water, but as the heat required to render it sufficiently plastic is greater than could be well endured without inflicting injury upon the soft tissues of the mouth, and subjecting the patient to pain in its application, it is customary, after having heated it sufficiently and packed the cup, to chill the surface by plunging it into cold water, and then introduce it quickly into the mouth. When the impression is secured, and the gutta percha has become somewhat rigid in the mouth, it should be removed and filled immediately with plaster, as it contracts rapidly in cooling.

Plaster of Paris, or gypsum, or technically, sulphate of lime, has been long employed in taking impressions of the mouth for entire dentures, and more recently and to a limited extent, for partial or broken sets. For entire pieces, it has almost wholly superseded the use of wax, and is better adapted for receiving an accurate impression of the mouth, whenever it is desired to secure a copy of all its parts in

their undisturbed relation to each other, than any material that has yet been employed.

When used for this purpose, it should be of the best quality, finely pulverized and well sifted, and should always be kept in a closed vessel, as the moisture which it attracts from the atmosphere impairs its property of hardening quickly when prepared for use. If impregnated with moisture, it should be first dried in a shallow vessel over a moderate heat before being used.

It is prepared for use by mixing with it a sufficient quantity of water to form a batter of about the consistence of very thick molasses, in which condition it hardens by a species of crystallization in from three to five minutes. The condensation of the plaster mixture is hastened somewhat by the admixture of a small quantity of the chloride of soda or common salt. The best method of preparing plaster, however, for the purpose under consideration, is to combine water with it in sufficient quantity to form, in the first place, a very thin batter, and then to stir or beat it constantly with a small spatula until it becomes sufficiently thickened to admit of its adhering in a body to the vessel in which it is mixed when the latter is inverted, and when one portion will retain nearly its form when heaped upon another. By this process of protracted beating, called sometimes "tempering," it is made tough and pasty, without having its plasticity impaired, and when introduced into the mouth in this condition, it adapts itself readily to the parts, hardens quickly, and is not liable, with ordinary care, to incommode the patient by running back into the fauces. So quickly, indeed, does it condense, that unless expeditiously introduced into the mouth, it will begin to "set" before the parts are fairly imbedded. When preparing it for use, therefore, the plaster should be mixed at the chair with the cup conveniently at hand, while the patient should be in proper position and in immediate readiness for the operation.

In view of the liability of the plaster to run back into the

fauces when the cup is pressed to its place in the mouth, producing nausea and involuntary retching and which is very liable to occur whenever the mixture is too thin or is improperly manipulated, it is recommended to instruct the patient to avoid swallowing while the plaster is in the mouth. Patients are also advised to breathe through the nostrils, but we see no good reason for this injunction. It should be remembered that, in the act of breathing through the nose, the velum palati or soft palate is depressed to cut off the passage of air through the mouth, and that it is thus brought more immediately in contact with any portions of plaster that may be protruding from the heel of the cup. The stimulus of contact will tend to produce involuntary contractions of the muscles of the soft palate and fauces, and thus portions of soft, or fragments of hard, plaster will be worked or drawn back into the fauces producing the very evils it is designed to avoid. If, therefore, patients are instructed at all in this respect, they should be advised to breathe naturally through the mouth, this channel affording less obstruction to respiration than that through the nostrils in the act of taking an impression.

Manner of Obtaining an Impression of the Mouth in Plaster for Partial Upper Dentures.—There are conditions of the mouth, incident to the presence of natural teeth within it, which would seem to preclude the use of plaster in taking an impression of the parts. Thus, if any number of the teeth remaining are small at the necks with enlarging crowns, or if they are irregularly arranged in the circle, having either an anterior, posterior or lateral obliquity, it would not only be difficult to detach hardened plaster from teeth so circumstanced, but the force necessary to remove it would inevitably break away portions of plaster from around the teeth. Another apparent objection to the use of plaster in these cases consists in the difficulty with which the impression is separated from the plaster model, it being necessary to cut away the former

by piecemeal, as it would be impossible to separate the two in the ordinary way.

The difficulties incident to the detachment of the plaster from the teeth in the mouth may be obviated in either of the following ways: 1. Take an impression first in wax, and with a metallic die and counter, obtained from a model of the parts, swage a plate of tin, brass, or silver, of the size and form of the intended base; coat the palatal surface of this temporary holder with a thin coating of plaster mixture, and apply it to the mouth in the manner usually employed in obtaining an impression.

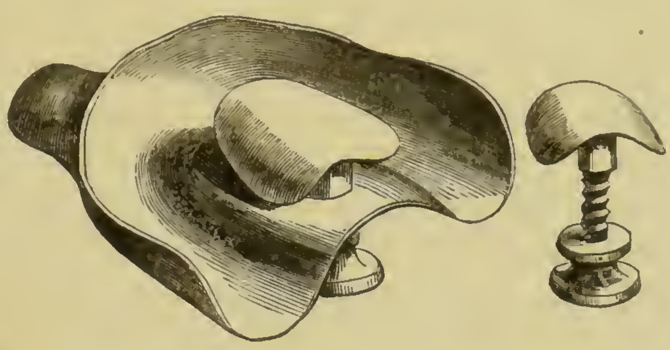
2. Take an impression of the parts in wax and cut away from the latter all those portions indented by the teeth, leaving only so much of the wax surface as corresponds with the palate and interspaces in the ridge; use this as a holder, and secure the impression by coating its surface, as before, with a thin layer of plaster batter. By either of the above methods an impression of those parts, only, on which the substitute is designed to rest, can be taken; the form and position of the teeth must be secured in a separate impression either with wax or gutta percha.

Notwithstanding the obvious objections already stated, many operators prefer, in taking impressions for partial cases, to imbed all the parts in plaster in the same manner as when wax is used, being careful to remove the plaster from the mouth before it has acquired the usual hardness. If the remaining teeth have contracted necks, or are placed irregularly in the arch, they may be partially encased in wax before applying the plaster; this will facilitate the withdrawal of the impression and preserve the form of the teeth; the wax, receiving the impress of the teeth, coming away with the plaster. The form of the cup used in these cases is the same as that represented in Fig. 21, the edge of which may be turned in a little at points to prevent the plaster from being dragged from the cup. The cup being filled with the plaster mixture is introduced into the mouth and carefully pressed

up until all the parts are fully imbedded. When partial hardening of the plaster has occurred, sufficient tractive force should be judiciously applied to the cup to separate the plaster from the teeth and soft parts, when it should be carefully removed from the mouth. If any portion of the plaster, essential to the form of the impression, should break away, the fragment or fragments may be secured and afterwards applied to the fractured surfaces.

Considerable force is sometimes necessary to separate the plaster from the teeth, and in the effort to remove the former, it is liable to part from the cup and remain fixed in the mouth; in which case it will be necessary to cut it away by piecemeal. This casualty may be effectually prevented by employing the form of cup shown in Fig. 24, contrived by Dr. Samuel Wardle, of Cincinnati, and used by him with entire success. It will be seen to consist of an ordinary holder, the cup portion perforated in the centre through which a small rod passes with a screw cut on one end, and the other surmounted with a concave flange, around and underneath which the plaster collects. The rod is formed with a shoulder resting on the palatal face of the cup, and is fixed in position by screwing the tap against the lower surface of the holder. A number of these centre pieces with shafts of various lengths, should be provided, in order that any desired elevation may be given to the cap or flange; for the latter is designed not only to confine the plaster, but also to carry it up into the roof of the mouth where the latter is very deep.

FIG. 24.



Manner of Obtaining an Impression of the Mouth in Plaster for Entire Upper Dentures.—The form of cup used in securing

an impression of the upper jaw for entire sets of teeth, differs in no essential respect from that recommended when wax is used for similar purposes. If the external border of the alveolar ridge is very deep, or there is considerable space intervening between the heel of the cup and the floor of the palate, a rim of wax may be placed along the outer margin of the cup, and extended across its posterior border, in order, more effectually, to confine the plaster within the cup and prevent its escape into the back part of the mouth before it has fairly reached the palatal vault. If the latter is very deep, with a marked excavation in its central and anterior portion, or if it presents somewhat the form of a deep fissure, the plaster may fail to be carried perfectly against the floor of the palate, or the air becoming confined within the central portion of the arch, when the plaster is pressed up, may displace the latter and form corresponding chambers in the impression. If these imperfections are but slight, they may be subsequently remedied either by filling up the cavity or cavities in the impression, or by trimming away at these points from the model. The better plan, however, where these conditions of the vault prevail, is to take up a small portion of plaster on the end of a spatula and apply it to the deeper portions of the arch just before introducing the cup.

The patient being seated as nearly upright in the chair as possible, with the head inclined slightly forward, the cup is filled with the plaster mixture and introduced quickly into the mouth, when it is pressed up slowly and gently until the parts are completely encased and portions of plaster are seen to protrude from all parts of the margins of the cup, otherwise the impression is liable to be imperfect either on its outer borders or on its palatal face. Immediately after introducing and pressing up the cup, the lip in front should be extended and drawn down over the cup, when gentle pressure, as the plaster is hardening, may be made upon the outside of the lip in front and at either side of the mesial line, to force the plaster more perfectly into the fosses which exist at these points.

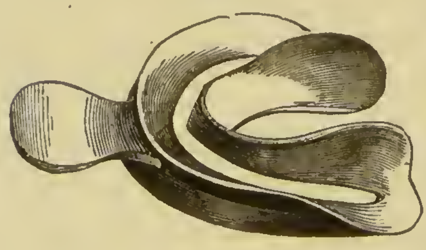
It is essential to perfect success in this operation, that the cup, after the parts are once imbedded, should be held perfectly stationary until the plaster becomes fixed, as the slightest movement, when the plaster is in the act of consolidating, will derange the impression and render it faulty. Again, if after the parts are imbedded, the operator discovers that they are not sufficiently encased, and the plaster has partially set, no further effort should be made to press the plaster up upon the parts, but the cup should be withdrawn and the operation repeated with fresh plaster.

If the operation has been successfully conducted, the plaster will adhere to the mouth, in most instances, with great tenacity, and it will be necessary to observe some caution in removing it, for, if forcibly detached, injury may be inflicted upon the soft parts by tearing away portions of mucous membrane; or the impression may be fractured or otherwise impaired. In addition to the means already adverted to in connection with the method of separating wax impressions from the mouth, resort is sometimes had to the following expedient:—The central portion of the cup being pierced with two or three small holes, a blunt-pointed probe is passed at these points through the plaster, before the latter has hardened perfectly, to the roof of the mouth. Into these passages the external air passes and diffuses itself between the surface of the plaster and the palate, when the impression may be readily detached. The author has succeeded best in detaching impressions in such cases, by upward and interrupted traction upon the handle of the cup, which, by depressing the heel of the same, more readily permits the introduction of air than by either of the methods commonly employed.

Manner of Obtaining an Impression of the Mouth in Plaster for Entire Lower Dentures.—Until recently, wax has been almost invariably used in taking impressions of the lower jaw. Plaster, however, may be used for the same purpose, and, by some, is esteemed superior to the former. The ordi-

nary wax holder as shown in Fig. 23, may be used, and which, being filled with the plaster batter thoroughly beaten until quite tough and pasty, is inverted and quickly introduced into the mouth and pressed down upon the ridge until the latter is completely imbedded; when sufficiently hard it should be removed in the ordinary way. A better form of cup, however, contrived expressly for the purpose by Dr. B. W. Franklin, is exhibited in Fig. 25. It consists of two chambers, or a double groove, communicating with each other by a fissure running from heel to heel of the cup. The groove corresponding with the curvature of the lower jaw is filled with plaster properly prepared, inverted, passed into the mouth, and pressed down upon the parts. As the cup is pressed down, portions of plaster will be forced through the fissure into the upper chamber,—this should be pressed down at all points along the groove with the finger, securing more perfectly, in this manner, the intrusion of the plaster into any irregularities or depressions that may occur in the ridge. Or, the empty cup may be placed in its proper position over the jaw and the plaster introduced into the upper groove and pressed down with the fingers through the fissure on to the ridge, filling the depending chamber.

Fig. 25.



CHAPTER III.

PLASTER MODELS.

AFTER an impression of the mouth has been secured in either of the ways mentioned in the preceding chapter, the next step in the process of constructing an artificial denture, is, to procure from the impression a representation of the parts in plaster. The copy thus secured is called a MODEL, and, if correctly obtained, is a true counterpart or fac-simile of all parts of the mouth represented in the impression.

Manner of Obtaining a Plaster Model from an Impression in Wax for Partial Dentures.—The impression in wax should be first trimmed by cutting away superfluous portions that overhang the borders of the cup, care being taken not to mar any essential part of the impression. The surface of the wax imprinted should then be uniformly smeared with a thin coating of oil applied with a camel's-hair brush. The oil should not be of too thick a consistence, nor applied in too large quantities, as it will collect in the more depending portions of the impression, and, failing to be displaced by the plaster, will leave the model imperfect at these points, especially at the coronal extremities of the plaster teeth. The cup is now surrounded by some substance that will confine the plaster and give proper form to the body of the model. For this purpose any material that is easily shaped may be used, as a thin sheet of lead or wax, paper, strips of oil or wax cloth, &c.

Before pouring the plaster, if it is desired to strengthen any of the plaster teeth,—as those adjoining the vacuities in the jaw, or such as are to be used in adjusting clasps, and thus secure them against accident in handling,—adequate

support may be imparted to them by placing short pieces of stiff wire vertically in the depressions made in the wax by the teeth, and which may be supported in an upright position by imbedding one end in the wax in the centre of the bottom of each cavity.

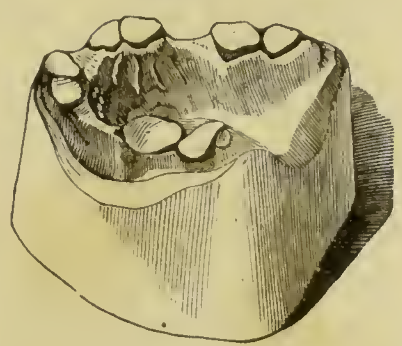
When the cup is properly enclosed, a batter of plaster, of somewhat thinner consistence than that used for impressions, is poured in upon the surface of the wax in sufficient quantity to give to the body of the model a depth of from one to three inches according to the particular requirements of the case. The plaster should not be poured directly or hastily into the cavities formed by the teeth, but upon points contiguous to them, and from which it should be allowed to run slowly into the depressions expelling the contained oil or air and filling them perfectly. When the plaster has become sufficiently hard, any portions overlapping the borders of the wax, and not essential to the form of the model, should be cut away and the two separated either by immersion in warm water, or by placing the model over the flame of a spirit lamp or upon a heated surface until the warmth imparted to the model renders the wax sufficiently soft to allow the former to be removed without fracturing the plaster teeth. The latter methods should be adopted whenever it is desired to obtain duplicate copies from the same impression, as by the use of hot water the impression is destroyed, the latter, however, being generally used when gutta percha is employed. When separated from the impression, the model should be properly trimmed and shaped with a knife-blade.

The general form of the body of a model is shown in Fig. 26. The walls, as it will be seen, are made as nearly vertical or parallel as will admit of the model being readily detached from the sand in the process of molding; for if made too flaring or divergent, the metallic die obtained from it will be more liable to crack or spread apart under the repeated strokes of a heavy hammer, or to rock under one-sided blows.

During the process of stamping or forcing a metallic base

into adaptation to the die,—which is a metallic counterpart of the model—the plate, when cut to the exact pattern of the parts to be covered by it, is frequently forced or dragged back toward the heel of the die, and is thus drawn from the teeth at the sides and in front. This displacement of the plate may be prevented by cutting away all of the plaster teeth from the model, leaving, however, enough of them remaining where they unite with the body of the model to form a shoulder to each tooth, as in Fig. 26. In this case, the plate should be sufficiently ample in its dimensions to partially overlap the border, when, as it is forced into adaptation, distinct indentations will be made in it corresponding exactly with the palatal curvatures of the teeth; the portions of the plate covering the cut ends of the teeth are then cut away with plate forceps or other instruments. If, however, the plate is of the exact size required before stamping, one or two plaster teeth upon each side of the model may be allowed to remain, against the anterior face of which the plate is made to rest, holding it stationary.

FIG. 26.



Manner of Obtaining a Plaster Model from an Impression in Wax for Entire Dentures.—The same general method is pursued in obtaining a plaster model from an impression in wax of either the upper or lower jaw for entire dentures, as that employed in partial cases. The general form of these pieces is represented in Figs. 27 and 28.

If it is desired to swage a rim to the plate, forming a groove or socket into which the plate extremities of the teeth are received, the model should be formed in the manner represented in the annexed cuts; in which it will be seen that an abrupt shoulder is formed on the external border of the model of the upper jaw (Fig. 27), but which on the lower (Fig. 28), is extended round the inner border also, as it is de-

sirable, in the latter case, to give a rounded edge to the lingual border of the plate, and which is accomplished in part by swaging in the first instance and afterwards by turning

Fig. 27.

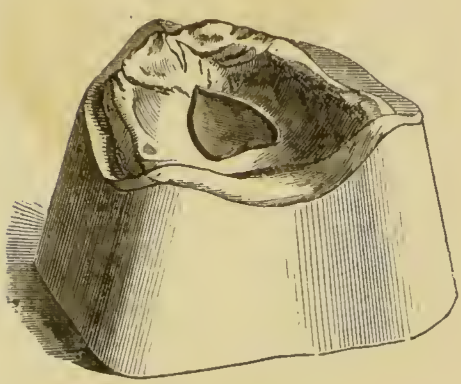
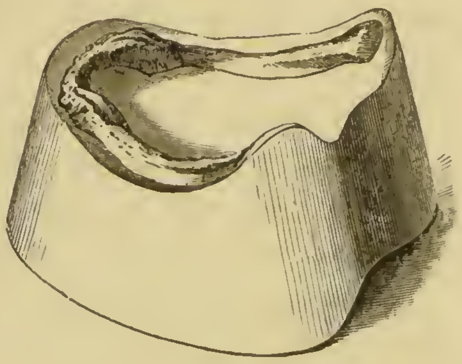


Fig. 28.



the edge down upon the plate with pliers or by other means. The model is prepared by adjusting a strip of softened wax around the border and cutting away from its upper surface in such a way as to form a groove, the bottom of which shall be on a line with the extreme edge of the base or plate and which should be indicated upon the model with a pencil mark before applying the roll of wax. Plaster may be substitued for wax, and should always be used whenever heat is applied to the model in the process of obtaining a metallic swage, as by the "dipping" method.

If the model is to be used in molding, the groove should be sufficiently open to permit the ready withdrawal of the sand, otherwise the die at this part will be imperfect; if, however, the face of the model is to be immersed in molten metal, securing first the counter-die, any form may be given to the groove that will best facilitate the operation of overturning the margins of the plate.

Rimmed plates are only required when single gum teeth or sectional or entire blocks are employed, or when plate teeth are mounted on a platinum base with continuous gum.

Whenever an air chamber is to be stamped in the base, the model should be prepared for the purpose before casting the

metallic swages. The general form and position of the central cavity or chamber in the arch is represented in Fig. 27. The model may be prepared in either of the following ways: 1. The form of the chamber may be cut from the wax or plaster impression; in which case the plaster will be raised at a corresponding point or points upon the model, and will have exactly the same form and depth as the cavity in the impression. 2. Cover the palatal face of the model with a sheet of wax equal in thickness to the required depth of the chamber, and cut out from this, at the desired point, the form of the cavity; fill the latter with plaster, and when hard remove the wax and trim the raised portion to the proper form. 3. Cut a pattern chamber, of the required form and thickness, from sheet wax or lead; place it in proper position in the arch and press down with the fingers or burnisher until it conforms to the contour of the palate; it is then fixed in place either by confining it with a small piece of wire or tack driven through it into the plaster, or by interposing softened wax or other adhesive material between the chamber and model. A small brush loaded with a varnish mixture passed round the edge of the chamber will insure sufficient adhesion of the latter.

The same general method as that when central chambers are formed is pursued in the preparation of the model when it is desired to construct lateral cavities in the plate. The form and position of these on the model will be indicated by inspection of the form of "lateral cavity" plates as exhibited in the chapter on "Entire Dentures."

There are other modifications in the form of cavity plates, some of which are obsolete; that known as "Cleveland's chamber," is still in limited use and will be described in a subsequent chapter, but does not require a model differing in form from the one described in connection with full dentures with central chambers.

Manner of Obtaining a Plaster Model from an Impression in Plaster for Partial Dentures.—The surface of the impression

in plaster should first be rendered hard by applying to it, with a camel's hair-brush, a uniform coating of varnish to prevent adhesion of the model. Two kinds of varnish are in common use,—a transparent and colored. The former is preferred for the reason that it penetrates the plaster more thoroughly, giving to it a greater depth of surface hardness, while the latter, if not sufficiently fluid, forms a somewhat superficial incrustation, which is liable to peel off in handling, leaving portions of the model unprotected. Either, however, if properly prepared and applied, may be employed.

FORMULA NO. I. *Transparent Varnish.*		FORMULA NO. II. *Colored Varnish.*	
Gum sandarach, . .	5 oz.	Gum shellac, . . .	5 oz.
Alcohol, ...	1 quart.	Alcohol, ...	1 quart.

The sandarach and shellac should first be freed from all impurities by careful picking and washing; they are then added to the alcohol and digested over a moderate heat until thoroughly dissolved. Other substances, as gum elemi, Venice turpentine, &c., have been recommended as additional ingredients, but they are not indispensable, and may be omitted without sensibly impairing the properties of the varnish.

After glazing the surface of the plaster impression with varnish, a thin and uniform coat of oil should be applied; it is then enveloped and the model procured in the same manner as when wax is used.

In separating the model from a plaster impression for partial cases, it will be necessary to cut the latter away in pieces, as any attempt to separate the two in the ordinary way would inevitably break away the plaster teeth from the model. The impression should be chipped away with great care to avoid defacing the model. To provide more perfectly against this accident, it is better to coat the impression with the colored varnish, as this will indicate, with greater certainty, the line of contact or union between the two pieces.

When separated, the model should be trimmed and formed in the manner heretofore described.

Manner of Obtaining a Plaster Model from an Impression in Plaster for Entire Dentures.—The preparation of a plaster impression of either the upper or lower jaw for full dentures, and the method of procuring a model therefrom, differ in no essential respect, except in the mode of separation, from the manipulations required when the impression has been taken in plaster for partial pieces. A model can, ordinarily, be readily detached from an impression of the lower jaw, but is not always so easily effected in the case of the upper. To accomplish this in the latter case, the model may be taken in the hand and the back of the handle of the cup tapped lightly with an instrument; or a small wedged-shaped instrument may be carefully forced between the model and impression at the posterior border of the latter until they part slightly, when they may be easily detached; before doing which, however, any overlapping portions of the model which may tend to bind the two pieces together, should be trimmed away. If any portion of the heel of the model is defaced by the introduction of the wedge, it may be afterwards remedied by restoring the contour of the parts with either wax or plaster.

After obtaining a model in either of the ways mentioned, the entire body of it should be glazed and hardened by applying to it a uniform coat of varnish. This protective covering will prevent the surface from wearing, render it more pleasant to the touch, facilitate its withdrawal from the sand, and give a more perfect mold. A model may be better prepared for permanent preservation by immersing it for a short time in a solution of carbonate of soda, by which its surface is converted into carbonate of lime and thereby rendered hard and durable; care must be taken not to introduce any of the bicarbonate of soda into the solution.

CHAPTER IV.

METALLIC DIES AND COUNTER-DIES.

A METALLIC DIE is a fac-simile or transcript of the mouth in metal, and is also a copy or likeness of the plaster model.

A metallic COUNTER-DIE is a copy of the impression and is a reversed image of the die and plaster model.

Manner of Obtaining a Metallic Die.—Two general methods are employed in procuring a metallic counterpart of the model: first, by *molding*,—secondly by a process termed "*dipping*."

Molding.—For this purpose sand is usually employed, though other substances, as Spanish whiting, etc., have been recommended. When sand is used, it should be fine and even grained, the best for the purpose being that used by brass founders. It is prepared by mixing with it sufficient water to render its particles somewhat adherent, so that when portions of it are pressed in the hand and then parted with the fingers, it will break away in well defined fragments. Excess of water should be avoided, as the vapor formed by the molten metal, when poured upon it, will displace portions of the latter and form cavities or blisters in the face of the die; nor should the sand be used too dry, as in that case it will crumble away in detaching the model.

Oil has been proposed as a substitute for water, in which case it is recommended to add one quart of the former to a peck of sand. It is claimed that the sand so prepared is always in immediate readiness for use.

The sand properly prepared, the model is next placed with its face uppermost on the molding board and surrounded with

a metallic ring. A common "wagon box," of which two or three sizes should be had, will answer every purpose. The sand should first be well sifted to remove the coarser particles, and then filled into the ring, packing it closely with the fingers around and over the model until even with the upper edge of the box. Some care must be observed in the management of the sand when packing it, for if made too compact, the vapor, formed in pouring hot metal, failing to pass out readily through the sand, will be confined within the cavity and form imperfections in the face of the die; or, if too loosely packed, the fluid metal when poured into the mold will, to some extent, permeate the pores of the sand and render the face of the die rough and inperfect.

The box, with the model encased, is then lifted above the board and the model dislodged by tapping it gently underneath with a small mallet or hammer until it parts from the mold. The uncertain and hazardous method, sometimes resorted to, of detaching the model by pressing it alternately backward and forward until loosened, and then lifting it from the sand, should never be practiced, as more or less deformity of the mold is unavoidably produced thereby.

It not unfrequently happens that the ridge on the plaster model of the upper jaw overhangs, forming corresponding depressions above, the excavations occurring more commonly in front and on each side of the mesial line. Whenever this form of the model exists, it will be impracticable to obtain a correct mold in the manner just described, since the sand becoming impacted in these excavations will be broken away and remain with the model when the latter is dislodged.

The difficulty mentioned, however, may be readily overcome in all cases by employing the sectional molding flask invented by Dr. G. W. Hawes, the several parts of which are represented in the accompanying cuts.

Fig. 29 represents the lower ring, composed of three movable pieces with flange extensions, which project in toward the centre. When used, this portion of the flask is closed

and the sections kept in place by pins passing through the joints. Inside of this ring the model is placed face upward, the ridge extending a little above the upper plane of the

Fig. 29.

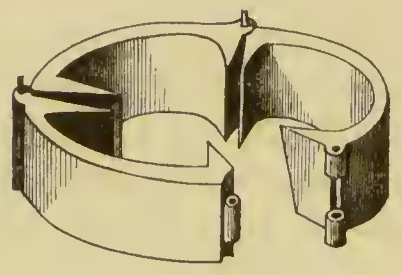


Fig. 30.

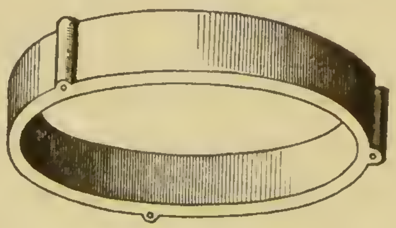
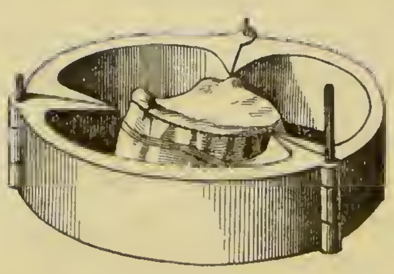


Fig. 31.



ring. Sand, well sifted, is then packed in around the model on a level with the most projecting points on the outside of the ridge as indicated by the dotted line in Fig. 31. The surface of the sand should be trimmed smoothly, and should be cut squarely and at right angles with the ridge, to prevent the sand from breaking away when the model is withdrawn. Very finely pulverized charcoal contained in a loose muslin bag, is now sifted over the exposed surface of the sand, to prevent the next portion contained in the upper ring from adhering. The plain ring (Fig. 30) is then placed over the one containing the model, and is filled with sand well packed over the face of the die. The upper ring is now carefully lifted from the lower one on a line with the pins, thus separating the two portions of sand, and again exposing the uncovered face of the model. One of the pins should then be drawn from the lower ring; the sections of the latter carefully unfolded, and the model withdrawn; when the ring may be again closed and confined by replacing the pin. The upper ring is then re-adjusted in its proper relation to the lower one, and the flask inverted; when the mold, if the process has been accurately conducted, will be found perfect.

In obtaining a mold from the model of a lower jaw, but

little difficulty will ordinarily be experienced in obtaining it perfect in the manner first described. The depressions at the posterior and inner border of the ridge are the points most liable to drag or displace the sand, and when the latter occurs, the surplus metal in the die at such points must be cut away with suitable instruments; or the cavities in the model may be so filled out with wax before molding as to permit the ready separation of the model without displacing the sand; in which case, also, it will be necessary, afterward, to trim the redundant metal from the die.

A die is more readily and accurately obtained from a model for partial dentures by cutting away the plaster teeth as before described. The displacement of sand where the ridge overhangs will, as a general thing, be unimportant in these cases, as the base but rarely more than partially overlaps the border.

When whiting is used in molding, it is unnecessary to mix water with it, as the moisture which it absorbs from the atmosphere will give to it the proper consistence.

Having obtained a mold in either of the ways mentioned, the metal designed for the die should be melted and poured carefully in upon the more prominent portions on the face of the former. If the metal is raised much above its fusing point, or the sand is quite damp, the former should be poured very slowly into the mold. It is better, however, that the sand should be partially dried before pouring the metal, and the die cast on the instant of the metal becoming sufficiently fluid. An observance of these precautions will protect the sand from the over-action of heat, prevent ebullition of the fused metal from the too rapid decomposition of the water of the sand, and will give a smoother face to the die, and secure the metal or metals from undue waste by oxydation. The opinion is entertained by some that greater skrinkage of the die occurs when the metallic substance of which it is composed is poured at a temperature much above its fusing point; the fallacy of this is made obvious by a moment's

reflection, as a simple example will show that any change affecting the face of the die, as a consequence of contraction, can only occur in the metal between its point of solidification or liquifaction—for they are identical—and its working temperature. Zinc, for example, melts at 773°. Now if its temperature be raised to 1200°, it will remain fluid until it reaches 773°, and in passing through the intermediate degrees of heat, it will, in obedience to gravity, adapt itself perfectly to all parts of the more depending portions of the mold; and this perfect continuity of the two surfaces will remain unaffected by the contraction of the metal until the latter commences to "set," or solidify, (773°,) after which, and not until then, the zinc begins to part from the face of the mold by contracting upon itself between 773° and the mean temperature of the air. So far as any change, by contraction, in the face of the die is concerned, therefore, it is obviously immaterial whether the zinc be poured on the instant of melting or at 1200°; the result will be the same in either case.

The author is indebted to Dr. B. W. Franklin for the following method of securing metallic dies and counters by a process which greatly facilitates the operation and insures accurate and satisfactory results:—"I take all impressions, full and partial, in plaster. A small hole, less than $\frac{1}{16}$ inch, is drilled through the highest point of the palatal surface of the impression, through cup and all; into this place two or three broom splints, cutting them off even with the surface of the plaster, to allow any vapors to pass off. I sometimes smoke the surface of the impression. Around the impression place sufficient putty to form a ring the size and height required for the die. Into this pour, at as low heat as consistent with the mobility required for sharp castings, the bismuth alloy known as Sir Isaac Newton metal, or, which is better in some respects, 8 parts bismuth and 4 parts each of tin and lead—the latter composition being a little harder. If a little judgment is exercised in pouring either

of the above alloys, a perfect die will be secured from moist plaster impressions without any drying. As the bismuth is expansive, and the alloy is hard and somewhat brittle, I run only a thin casting, not more than ½ inch in thickness, over the highest portion of the impression. I have cast iron or brass heads made 3¼ inches in length, 3 inches in diameter at large end, and 2 inches at the other; the large end is flat and well coated with common tinman's solder. This head is heated until the solder begins to soften; it is then placed in a pan or other convenient vessel, and the die, face side up, is placed upon the tinned surface. When the die begins to melt, and perfect union is secured, cold water is dashed upon the die and head; and thus we have a sharp die, with an iron head, to sustain the force of the blow in stamping the plate, and by this means preventing any spreading of the face of the die or liability of breaking in the process of swaging.

"I now take sheet lead of the thickness of about No. 24 standard gauge, and adapt it to the face of the die by means of a wooden mallet or burnisher, or other convenient means. Trim the lead plate to the size required for the plate to be stamped; when the lead plate is nicely fitted, remove it carefully from the die, and place it in a ring or narrow molding flask, the palatal side up; now gently stamp molding sand into the plate and flask up level with the edges of the flask; then reverse the flask and cut the sand away *clean* for ½ inch or more down to the edge of the lead plate all around. Around the plate place a common molding ring sufficiently large to form the counter, which is made by pouring melted tin or lead (or any alloys of these metals) on to the lead plate, being careful not to run the metal so hot as to melt the lead plate. When the counter is cool enough to handle, the adhering sand is brushed or washed away; the die is then placed into the bed or counter, and, with a moderate sized hammer, give one or two sharp blows to bring the die and counter together. In swaging gold plates, two or three or

more dies may be required; these may be made either by running the die-metal into the impression (if not broken), or by running into lead plates, gotten up as before described, reserving, of course, the first die and counter for the final swaging of the plate. I have gotten up a die and counter from the impression, with the aid of an assistant, in the foregoing manner in twelve minutes. I usually get out my die immediately after taking the impression; adapt a wax or gutta percha plate to the die, and get the articulation before the patient leaves the office."

Dipping,—By this process the counter-die is first obtained, and from this the die. For the purpose, two or three sheet-iron pans varying in size should be provided, measuring from three to five inches in diameter, and from two to three inches in depth, the open ends of which should be somewhat larger than the bottoms. The metal for the counter is melted and poured into the pan, and immediately before "setting," the model, being unvarnished and previously well dried, is immersed, face downward, until all parts of the palatal arch and ridge are imbedded in the metal. The chamber, as well as the groove around the outside of the ridge concerned in the formation of a rim to the plate, should, in this case, be formed in plaster.

Ordinarily, the conformation of the ridge above and below is such as to render it impracticable to remove the model from the metallic matrix without injury; hence two or more models will be required whenever this method is practiced.

After the counter-die and model are separated, all traces of plaster should be carefully washed from the matrix, and the latter surrounded with a sheet-iron ring forced slightly into the counter immediately outside of the cavity formed by the model; into this the metal for the die is poured, filling the matrix and ring.

If the metal or alloy forming the die fuses at the same, or a higher, heat than that composing the counter, the matrix should be protected from adhering to the die by coating its

surface uniformly either with lamp smoke, or a thin mixture of whiting and water or alcohol.

Counter-Die.—A counter to the die is generally obtained directly from the latter, and may be procured in either of two ways. 1. The die is placed, face upward, upon the molding-board, and sand, prepared as in molding, built up around it, leaving only the ridge and palatal face exposed. It is then encircled with a cast or sheet-iron ring two or three inches deep, its edge imbedded in the sand to prevent the escape of the fluid metal; into this the metal for the counter is poured until nearly or quite full. 2. The metal for the counter may first be poured into a sheet iron vessel of proper size, and, immediately before setting, the face of the die is immersed in the liquid mass, and held perfectly stationary until solidification of the counter takes place. The method of procuring a counter die directly from the plaster model, as in the process of dipping, has already been described.

The metal commonly employed for the counter is lead, although other substances, as tin, type metal, some of the more fusible alloys hereafter to be mentioned, &c., are sometimes employed. When the counter is taken by pouring the metal or metals composing it upon a die fusing at a low heat, some caution should be observed lest the two pieces adhere by partial fusion of the die. In such cases, the surface of the die should be well protected with lamp smoke or whiting; the lead should be poured at the lowest practicable temperature, and the conduction of heat facilitated by surrounding the die with a heavy cast-iron box or ring. To avoid incurring any risk, however, the counter-die, if composed of a less fusible metal or compound than the die, may be first obtained directly from the model, and the die obtained from this as in the process of dipping; or, a counter of lead, previously taken from a zinc or other more infusible die, may be used.

During the process of forcing a plate into adaptation to the form of the mouth with swages, it not unfrequently happens

that the marginal portions of the former become wedged or immovably fixed between the outer border of the die and corresponding portions of the counter before its central portion is forced into contact with the palatal surface of the former, thus rendering it difficult to conform the plate accurately to the parts without the application of sufficient force to deface or otherwise mar the form of the die. In such cases, the central portion of the plate may be first swaged with a *partial counter*, which is made to receive only the palatal portion and upper surface of the ridge of the die. After forcing the central part of the plate into adaptation with the partial counter, the process may afterwards be completed with a full counter after having turned the edges of the plate down upon the outer border of the ridge with a mallet and pliers.

As before remarked, preference is usually given to lead in the formation of a counter die, mainly on account of its greater softness. This property in a counter is practically important. In the process of forcing a metallic plate into adaptation to the mouth, partial displacement or yielding of either the die or counter, or of both, necessarily occurs, and it is scarcely necessary to remark that whatever change of form is produced should take place wholly in the counter, otherwise deformity of the die must ensue.

Essential Properties of a Die.—There are certain properties which it is indispensable that a metallic die should possess, more or less perfectly, in order to answer fully the requirements of the dentist.

1. A die should be sufficiently *hard* to resist any necessary force applied to it in stamping the plate without suffering any material change in the form of its face, by which latter term is meant that portion of the die with which the plate is brought into contact. This property is most indispensable in those cases where the arch of the mouth is very deep, the ruga prominent and sharply defined, and where the alveolar ridge is marked by angular and abrupt prominences and de-

pressions. In such cases, if the die is not sufficiently resistant, the points most prominent upon its face will be bruised or battered down, while the plate will fail to be forced perfectly into the cavities or depressions, and its co-aptation to the mouth, to that extent, rendered faulty. The cases in which a less degree of hardness is admissible is, where the arch of the mouth is broad and shallow, the ruga imperfectly defined, and the ridge regular and symmetrical. The conformation of the mouth, therefore, will, in respect to the property of hardness, admit of some latitude in the choice of the metal or alloy employed in the formation of a die.

2. Another important property of a metallic die is *non-contraction*, so far, at least, as this is attainable. Inasmuch as the successful adaptation of the plate depends, in a great measure, upon an accurate representation of the precise form of the mouth in the die, it is of the first importance that the latter, other essential requisites being secured, should be composed of some metal or metals having the least possible contraction in cooling. Contraction is, in varying degrees, common to all metals exposed to a decreasing temperature, and it is impossible, therefore, to obtain a perfectly faultless copy of the mouth in metal. Fortunately, as well for the expert as the unskilled manipulator, the unavoidable shrinkage incurred is partially or wholly compensated for by the expansion of the plaster and the yielding condition of the soft tissues of the mouth, but under no circumstances should the accommodation afforded by the condition last mentioned encourage negligence or unskillfulness in the use of all available means necessary to secure the most accurate adaptation of the base. Ordinarily, a moderate degree of contraction will not materially impair the fit of a plate; on the contrary, in the case of the upper jaw, it sometimes favors its adhesion and retention in the mouth. Cases, on the other hand, frequently occur where the least practicable amount of shrinkage, even at the partial sacrifice of other properties, becomes indispensable in the die.

3. A third important requisite of a die is *fusibility*. Aside from the convenience incident to the use of metals which fuse at a low heat, there is another consideration favoring this property of more practical importance. It is well known that all metals expand by heat and contract by cold. In obedience to this law, metals fusing at a high heat suffer a greater aggregate contraction than those melting at a lower temperature, and, as between two metallic bodies of equal dimensions, liquifying at different temperatures, the difference in contraction will correspond exactly with the difference in the number of degrees through which each passes from the point of solidification to the mean temperature of the air, allowance being made for the difference in their ratios of contraction. Two dies, one composed of copper and the other of zinc will serve to illustrate. Fused copper solidifies at 1900°; in cooling, therefore, it contracts through over 1800° to reach a working temperature; while zinc, fusing at 773° contracts through only about 700° to reach the same temperature. As before stated, the difference in the contraction of metals will be somewhat modified by that in their ratio of contraction, but it will always be found that the more fusible metals have the least aggregate shrinkage whenever any considerable disparity exists between their fusing points. It is in accordance with the principles here set forth, that the more fusible alloys, some of which melt at remarkably low temperatures, are employed whenever it is important to obtain a die as nearly the exact counterpart of the model as possible.

4. Finally, a die should be sufficiently *cohesive* to resist the repeated blows of a heavy hammer without parting or cracking. Many metals, as antimony, bismuth, &c., in other respects suitable for dies, are objectionable on account of brittleness. But it must not, therefore, be inferred that all metals that are denominated brittle are inadmissible for this purpose; for zinc, which, in its ordinary condition is ranked as a brittle metal, and type metal, which is always so, are in no danger of being forced asunder or of suffering displace-

ment when in the compact form of a die, provided the force used in swaging is judiciously applied or proper form and sufficient depth are given to the body of the die.

To recapitulate briefly: a die should be formed of some metal or alloy that has a surface hardness sufficient to resist compression; that fuses at a low temperature; that does not, in any material degree, contract in the act of cooling; and whose particles adhere with sufficient cohesive force to maintain perfectly its integrity of form under the hammer. Any one or two of these properties are readily attainable in the same die, but no one known metal or alloy combines all of them perfectly. Thus either cast-iron, brass, bronze, or cannon metal, would form an excellent material in respect to surface hardness, and, in the compact form of a die, would be sufficiently cohesive, but few enjoy convenient facilities for melting them; besides, their great contraction consequent upon their high fusing point, would render their employment entirely inadmissible. Again, certain alloys, as those composed of lead, tin, and antimony or bismuth, are eminently suitable on account of their extreme fusibility and comparative exemption from shrinkage, but they gain these properties at the expense of that degree of hardness necessary to resist compression. Tin, in its uncombined state, is ordinarily, sufficiently fusible, tenacious, and non-contractile, but is too soft and yielding when forcibly compressed. Antimony and bismuth are sufficiently hard, fusible and non-contractile, but are objectionable on the score of extreme brittleness.

Any metallic substance that combines most perfectly the several properties referred to, is, therefore, best adapted to the necessities of the mechanical operator, and experience has universally accorded pre-eminence in this respect to zinc. It presents a more resistant surface to the blow of a hammer than either copper or brass; three times more so than that of tin; and more than double that of type metal. As it usually occurs in commerce, it may be classed as a brittle metal, but when annealed, it is tough and malleable. It melts

at a heat (773°) which may be readily commanded and contracts but little in cooling. Prof. Austin has demonstrated by actual experiments that an average sized zinc die, measuring two inches transversely, contracts 27·1000ths of an inch from outside to outside of the alveolar ridge, being equivalent in thickness to three ordinary leaves of a journal. Prof. A. remarks: "In the first case, (upper jaw,) the plate would 'bind' and if the ridge were covered by an unyielding mucous membrane, it would prevent accuracy of adaption. In the second case, (under jaw,) the plate would have too much lateral 'play' and consequently lack stability. Again, in a moderately deep arch, say a half inch in depth, the shrinkage between the level of the ridge and the floor of the palate will be nearly 7.1000ths—rather more than one leaf of the journal. In the deepest arches, this shrinkage becomes a serious difficulty; in the shallower cases, it is not of much moment, as there is no mouth so hard as not to yield the 1 or 2·1000ths of an inch."

As before stated, a moderate degree of shrinkage in the die may, in certain conditions of the mouth, practically favor the adhesion and permanent retention of a plate applied to the upper jaw. The conditions alluded to, and which prevail in a greater or less degree in all cases, are soft and yielding ridge and comparatively hard and unimpressible palate. Now, if, in the first instance, the plate is swaged into uniform contact with all parts of the jaw, it will be readily perceived that, if pressure is made over the ridge on one side, the latter will yield, while the central portion of the plate, meeting with a fixed point of resistance at the floor of the palate, will "ride" upon the latter and thus throw the plate from the ridge on the opposite side of the jaw. If, however, a space equal to one or two thicknesses of the plate exists between the latter and the roof of the mouth as a consequence of contraction in the die, the plate, as it is carried against the palate in the act of exhausting the air from beneath it, will, at the same time, forcibly compress the ridge, securing

thereby a more resistant basis along the border, and providing more certainly against displacement of the base on the application of forces brought to bear upon it in mastication.

The extent to which the shrinkage of a die may be admitted in any given case, will depend partly upon difference in the conditions heretofore mentioned in the soft parts of the mouth, and in part, also, upon the general configuration of the jaw. In a medium-sized mouth, with a depth of say half an inch to the arch, a moderately soft ridge and resisting palate, the shrinkage incident to zinc will be unimportant, and in many cases will be advantageous. If, however, the vault is very deep, even though there be a yielding ridge, the unavoidable contraction of a zinc die will throw the plate so far from the arch as to render it difficult for the patient to exhaust the atmosphere from between it and the floor of the palate, and even when the latter is practicable, the plate will bind with such force upon the outer border of the ridge as not only to produce pain and irritation of the compressed parts, but the resistance afforded at these points will be sufficient, in many cases, to break up the adhesion and force the plate from the palate. Again, as an extreme case, if the ridge and palate are somewhat uniformly unyielding, and the palatal vault is, at the same time, very deep, a zinc die can only be made available in bringing the base as nearly into adaptation as possible, after which the operation may be completed with a swage having a less degree of shrinkage, and which, as a mere finishing die, need not necessarily be so hard as zinc.

In conforming a plate to the lower jaw, the die should be as free as possible from contraction in all cases. The greatest shrinkage in such cases will be between the posterior extremities of the ridge, giving too much lateral play to the plate; in addition to which the posterior and inner edge of the base, projecting out from the ridge, will obstruct the free action of the tongue, while the latter will tend to lift it from the ridge and render it unstable. These conditions may be partially remedied by turning the edge of the plate in

against the ridge with pliers; but this expedient should never be resorted to in any case whenever it is practicable to secure a correct adaptation by swaging.

In all cases in which a zinc die fails to bring the plate into proper adaptation to the parts, either of the following metallic compounds may be used to complete the process after partial stamping with zinc.

Type Metal.—Lead, 5 parts; antimony, 1 part. Fuses at 500°; contraction less than one-half that of zinc; more compressible than the latter, and very brittle.

Babett, or Anti-friction Metal.—Copper, 3 parts; antimony, 1 part; tin, 3 parts. First fuse the copper, and then add the antimony and tin. Melts at a moderately low heat; contracts but little; is brittle, but may be rendered less so by adding tin.

Zinc, 4 parts; *tin,* 1 part. Fuses at a lower heat, contracts less in cooling, and has a less surface hardness than zinc.

Tin, 5 parts; *antimony,* 1 part. Melts at a lower heat than either of the preceding alloys; contracts but slightly in cooling; is harder than tin, and sufficiently cohesive. It is readily oxydized, and should be poured as soon as melted.

Fusible Alloys.—The following tabular view of the more fusible alloys, the respective properties of which are deduced from actual experiments, is given by Professor Austen, in a paper on "Metallic Dies."* Zinc is introduced into the table for the purpose of comparison.

	Melting Point.	Contractility.	Hardness.	Brittleness.
1. Zinc, ...	770°	·01366	·018	5
2. Lead, 2, Tin, 1, ...	440°	·00633	·050	3
3. Lead, 1, Tin, 2, ...	340°	·00500	·040	3
4. Lead, 2, Tin, 3, Antimony, 1, ...	420°	·00433	026	7
5. Lead, 5, Tin, 6, Antimony, 1, ...	320°	·00566	·035	6
6. Lead, 5, Tin, 6, Antimony, 1, Bismuth, 3, . .	300°	00266	030	9
7. Lead, 1, Tin, 1, Bismuth, 1, ...	250°	·00066	·042	7
8. Lead, 5, Tin, 3, Bismuth, 8, ...	200°	00200	·045	8
9. Lead, 2, Tin, 1, Bismuth, 3, ...	200°	·00133	·048	7

* American Journal of Dental Science, vol. vi., p. 367.

Professor A., in commenting on the preceding table, observes: "The last column contains an approximate estimate of the relative brittleness of the samples given. As in the other columns, the low numbers represent the metals, so far as this property is concerned, most desirable. Those marked below 5 are malleable metals; those above 5 are brittle; zinc, marked 5, separates these two classes, and belongs to one or the other, according to the way in which it is managed." Allusion is here made to the process of annealing zinc, and which has already been adverted to when considering the latter metal in a former part of the work. The special method employed is thus described by the author already quoted. "The simplest way to anneal a zinc die is to place it in the melting ladle with about a tablespoonful of water, removing it in thirty seconds after the water has boiled away. If the fire is a very hot one, remove it immediately on the disappearance of the water. It will often happen that the die is annealed in the process of taking the counter-die. This will more certainly occur when Nos. 7, 8, or 9, (see table,) are used for the counter. For example, take tin: using a mass twice the size of the die, should it be heated to 540°, (100° above melting point,) it would not, allowing for loss of heat by radiation and contact with the cast-iron ring, (if one be used,) heat the zinc beyond 330°. Lead, cast as cool as it could possibly be poured, unless in a very heavy ring, (such as a 'cart wheel box,') or in quantity too small for a well-shaped counter, would be apt to raise the zinc at least to 400°, and so impair its malleability, whilst, if poured as hot as many are in the habit of doing, the zinc will remain as brittle as when first cast."*

* To Professor P. H. Austen, whose various contributions relating to the mechanical department of practical dentistry have done much to unfold and elucidate the principles involved in the practice of this important specialty, the author would acknowledge his indebtedness for many of the valuable data and practical suggestions that may be found embodied in the foregoing chapter; and had not the limited space assigned us, compelled a condensation of his views on the subject of metallic dies and counters, we might have done the reader an essential service by transferring to our pages many of his eminently practical observations on the subject entire.

CHAPTER V.

PARTIAL DENTURES.

The almost unlimited modifications in the form of substitutes designed to supply the loss of a portion only of the natural teeth, and the difficulties oftentimes incident to a harmonious arrangement of the teeth of replacement, as well, also, as the impracticability of always securing a perfectly satisfactory and efficient antagonism or closure of the artificial with the natural organs, frequently surround this process with peculiar embarrassments, and often render their successful application extremely difficult. They will, accordingly, be found to demand of the operator the exercise of greater skill, ingenuity, and discrimination than are usually required of him in the construction and application of entire dentures.

The various means employed in fixing or retaining partial sets of teeth in the mouth will be first considered. Either of the following methods may be adopted according to the preferences of the operator, or the requirements of individual cases. 1. *Pivoting an artificial crown to the root of a natural tooth.* 2. *Clasping to the natural teeth.* 3. *Wood pivots adjusted to tubed plates.* 4. *Pivoting plate to the roots of the natural teeth.* 5. *Atmospheric pressure.*

PIVOT TEETH.

The process of pivoting or grafting an artificial crown upon the root of a natural tooth has been long practiced, and when skillfully performed with intelligent views of the various con-

ditions which recommend and justify the operation, it affords a valuable and unobjectionable means of substitution. The success of the operation will be greatly modified by the following circumstances:

1. *The Condition of the Root, its Appendages, and Surrounding Structures.*—If the root to be pivoted is strong, well formed, and securely attached to the jaw, a living, healthy nerve present, and the peridental membrane free from disease, the operation will be attended, in a large preponderance of cases, with the happiest results, and in respect to utility, comfort, and appearance, is superior to any other mode of substitution. If, however, the nerve of the tooth has been previously destroyed by disease, and inflammation and suppuration of the adjacent tissues have supervened, the probabilities of complete success will be greatly diminished; for although these latter conditions may have been subdued for the time being by appropriate treatment, yet that a latent predisposition favoring their recurrence exists is manifest from the frequency with which unfavorable results follow the operation of pivoting even under circumstances so apparently favorable.

In no case, we are convinced, unless under circumstances of peculiar exigency, should an artificial crown be attached to a root whenever the latter is complicated with incurable disease of the investing membrane or alveolar abscess. It may be safely affirmed that the failures so common to this method, and the consequent disrepute into which it has deservedly fallen, as ordinarily performed, is fairly chargeable not so much to unskillful manipulation as to a want of proper appreciation of the pathological conditions which clearly contra-indicate its employment. The facilities enjoyed by the dentist of the present day in the employment of the various approved methods of replacement, other than the one under consideration, no longer make it either necessary or pardonable to subject the patient to a course of treatment which unavoidably necessitates a perpetual drainage of de-

praved and offensive pus either through fistulous openings in the gum or through channels provided by art.

As respects the surrounding structures, it is well, with a view of removing any disturbing causes, to institute a careful examination of the mouth before inserting pivot teeth, and if any of the remaining teeth are found carious or incrusted with tartar, or the mucous membrane and gums are inflamed or otherwise diseased, they should be treated in accordance with the indications furnished by the particular morbid conditions present.

2. *Diathesis of the Patient.*—Cases frequently occur where there exists a marked constitutional predisposition to inflammation, in some of its various forms, from the operation of very slight causes, and although it is not always practicable to determine the exact degree of this tendency in all cases, yet some evidence of its existence may be acquired by inquiry of the patient as to the usual termination of injuries inflicted upon any portion of the body, as, whether they heal kindly by the ordinary process of reparation or tend to inflammation and suppuration. Whenever this predisposition exists in any marked degree, the operation, though other conditions may favor success, is liable at all times to terminate unfavorably, and, therefore, if performed at all, it should be done in the most careful manner and only under circumstances that promise the best chances of success. It is well, in cases characterized by a phlogistic habit of body, to first reduce the system somewhat by appropriate antiphlogistic treatment, and in no case should more than one tooth be inserted at a single sitting, and it will be prudent, in many cases, after having prepared the root, to defer the completion of the operation for a few days, or to adjust a tooth temporarily with a pivot loosely fitted, until the irritation, unavoidably produced by filing, drilling, &c., has completely subsided.

3. *Manner of Performing the Operation.*—The healthy condition of the root and contiguous parts, and the ultimate utility of the substitute, may be very materially prejudiced

by careless, hurried, or injudicious manipulation; as where the remaining portions of the natural crown of the tooth are violently removed with excising forceps, or by the unskillful use of files in dressing the root, or drills in enlarging the central cavity, or by undue or misapplied force in the final adjustment of the artificial crown, or finally, by a faulty position of the tooth of replacement by which the root is subjected to injurious strain either by lateral pressure or premature closure against those of the opposite jaw. By the operation of either or all of these causes, disease of a more or less intractable character may be induced which will impair the usefulness of the artificial organ and subject the patient to much present and future distress and annoyance.

The Roots of Teeth to which Artificial Crowns are usually Attached.—The operation of pivoting artificial substitutes is necessarily limited in its application, being confined to the front or single-rooted teeth,—usually to the incisors and cuspidati of the upper jaw. The same class of teeth of the inferior maxilla, though sometimes used for the purpose, are not favorably formed or situated, having a posterior inclination in the arch which renders ready access to them with the drill difficult or impossible, while the small size and flattened condition of the roots preclude the use of pivots of sufficient strength. Nor are the roots of the bicuspids of either jaw ordinarily admissible, as the lateral compression of these fangs do not admit of the use of pivots of adequate size and strength to secure them against accident in mastication. Comparatively speaking, the roots best adapted to this process are those of the superior central incisors, and cuspidati or canine teeth.

Preparation of the Root.—In the process of preparing the root for the attachment of an artificial tooth, all remaining portions of the natural crown should first be removed with suitable instruments. If the cervical portion of the tooth is comparatively sound and unbroken, this may be most expeditiously accomplished, and with less risk of injury to the

root, by employing a very fine saw attached to a steel frame or carrier as shown in Fig. 32. The saw should be narrow enough to enable it to take a curvilinear direction in cutting, as this will enable the operator to separate the crown nearly or quite on a line with the arched margin of the gum, thus

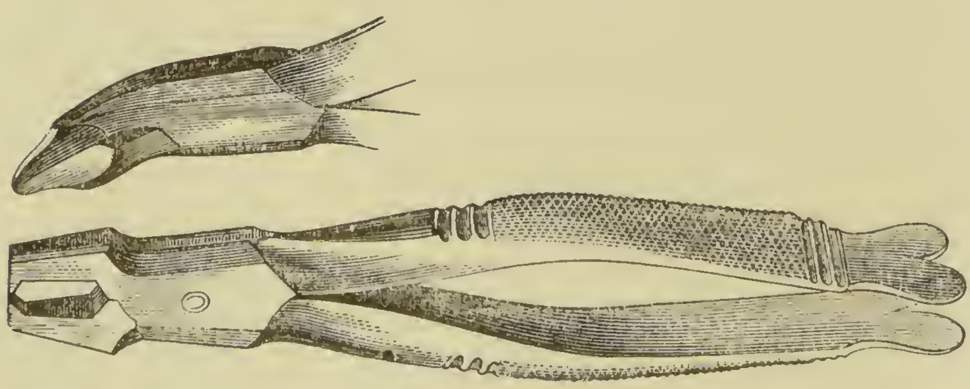
Fig. 32.

dispensing, in a great measure, with the use of the file in the final dressing of the cut end of the root.

The saw should be passed along the side of the tooth to the gum and the crown separated either by cutting directly across to the opposite side, or as nearly on a line with the curvature of the anterior and posterior margins of the gum as possible without wounding the latter. During the operation, the saw should be kept constantly wet, and the crown should be supported by the fingers.

If the remains of the crown are friable, or if they consist of but fragmentary portions of enamel, they may be readily cut away with excising forceps, two forms of which are exhibited in Fig. 33. The one having square transverse cutting

Fig. 33.



edges, closing at right angles with the shaft, is generally employed. Serious, if not irreparable injury may be inflicted by the careless or unskillful use of this instrument, either by producing so violent a concussion as to induce, in some in-

stances, incurable disease or absolute necrosis of the root; or by fracturing the latter in such a way as to unfit it for the reception of the pivot-crown. The forceps, therefore, should never be used to excise the crown with a single cut whenever any considerable portion of the root at the gum remains unaffected by disease, and even when the latter is friable or partially destroyed by decay, they should be used with great caution, cutting or chipping away small portions at a time, until as much of its substance is removed as is practicable with the forceps.

After the use of the saw or excising forceps, any remaining portions projecting beyond the free margins of the gum should then be removed and proper shape given to the end of the fang with a file. A half-oval file, with a sharp and tolerably fine cut running obliquely across its convex surface, is the best for the purpose, and when in use, it should be kept constantly wet and free from clogging particles of bone. The end of the root should be filed down, anteriorly at least, a little below the free margin of the gum, care being taken not to lacerate its peridental attachment; in this way the artificial crown, when adjusted to the root, will unite so intimately with the gum in front as to render exposure impossible. The surface of the root, prepared in this manner, will present a concavity corresponding with the festoon of the gum.

If a living nerve remains in the root it will not ordinarily be practicable, unless there is partial obliteration and consequent recession of the pulp cavity as the result of ossific deposits, either to saw off the root on a line with the gum or even transversely, or to file the root even with the gum without inflicting insufferable pain. It will be necessary, therefore, either to remove the nerve through the carious opening in the crown before the latter is removed, or, if not exposed by the operation of sawing or filing, through an opening into the pulp made with a drill or cutting instrument after excision.

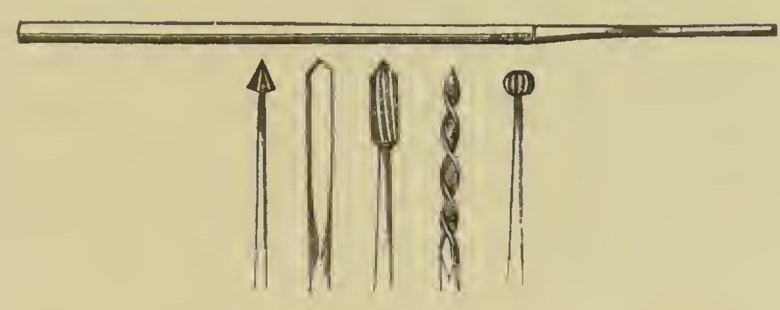
The use of arsenic for the destruction of the nerve pre-

paratory to its removal, though sometimes employed, is liable, under the most cautious management, to result in periodontitis and ultimate suppuration of the surrounding tissues, and should, therefore, never be used if circumstances admit of its removal by direct operation with instruments. By the latter method, the vitality of the root, through its peridental circulation, will be better preserved. Its extirpation may generally be readily effected with the use of a three or four-sided, barbed, untempered broach, which, being small enough to penetrate freely to the apex of the fang, is thrust quickly to the bottom of the canal, rotated, and withdrawn; when, if the entire nerve does not come away adherent to the broach, the operation may be repeated, with comparatively little pain, until all portions of it are removed. A method more especially recommended by Prof. Taft, in his recent work on "Operative Dentistry," page 234, is the following: "Take a very fine untempered steel wire, round and smooth, not larger than 34 to 36 of Stub's gauge-plate; flatten the extreme point, and turn it to an angle of from thirty to forty degrees; place the edge of this against one wall of the canal at the point of exposure of the pulp; press it steadily up the canal, with its edge bearing against the wall, as far as it will go, and then twirl it suddenly round: thus an excision is effected near the point of the fang, when the pulp with the instrument may be drawn away together; or, if not thus drawn, it may be caught with some fine point, and removed without pain. This manner of introducing the instrument, too, causes less pain than either of the others, for there are no sharp edges or points presented in passing the instrument up the canal, to cut or lacerate the pulp. In the removal of the pulp from the teeth of young persons, care should be taken lest the instrument pass entirely through the foramen, at the apex of the fang; but with adults, there is little or no danger of such an accident."

The nerve being removed, the canal of the root should be enlarged for the reception of a pivot. This is effected with

a suitable broach, or with drills of various forms. When the canal presents the form of a cleft or fissure, a spherical or cone-shaped bur-drill should be used; if, however, the nerve cavity approaches a cylindrical form, the operation will be more speedily performed with a four-sided broach, or what is still better, a spear-pointed or spiral drill; all of which are exhibited in Fig. 34. The natural opening in the fang

FIG. 34.



should be enlarged to the depth of from one and a half to two or more lines, according to the length of the root; and the orifice should be made large enough to admit a pivot of sufficient size to secure the crown firmly in position. The direction of the drill in cutting should follow closely that of the natural canal in the root, since but a slight deviation in this respect may endanger the integrity of the latter by too great a thinning, or actual perforation, of its walls. In all cases, however, where the direction of the canal will admit of it, the shaft of the instrument should be held steadily on a line with the circle formed by the cutting edges of the adjoining teeth, and either equi-distant between the latter or with such a lateral inclination as will give to the tooth of replacement a symmetrical arrangement in the arch. During the operation, the drill should be kept constantly wet, and loose particles of bone should be washed from the cavity by occasional injections of water.

The unenlarged portion of the nerve canal between the bottom of the pivot cavity and the apex of the root should

next be thoroughly closed with gold in the manner usually practiced in fang filling,—all diseased conditions associated with the root, if such exist, having been previously subdued by appropriate treatment.

Fitting the Crown.—The pivot crown selected for any given case should correspond, as nearly as possible, in size and general configuration with its fellow of the opposite side, or, where several are inserted, with the form and size of the natural organs which they represent. The tooth or teeth of replacement should also harmonize in color with those immediately adjoining. The cervical portion of the crown applied to the root should correspond, as nearly as possible, in dimensions with the filed surface of the root, and the adaptation of the two surfaces should be sufficiently accurate at all points to afford a firm basis for the crown, and, at the same time, to exclude perfectly all particles of alimentary or other solid substances, the decomposition of which would tend to the decay or disease of the root, or become offensive in the mouth. To secure such a coaptation of the articulating surfaces, more or less filing of the root and grinding from the base of the crown will be required, so that while uniform contact of the surfaces is secured, the artificial crown will be made to occupy its proper relative position in the arch.

The articulation of the crown and root may be very accurately obtained in the following manner: Attach to the crown a temporary pivot of wood that may be easily applied and removed; coat the surface of the root uniformly with some pigment, as carmine, rouge, or rose pink, and apply the crown, with pivot attached, to the root; the points of contact will be indicated upon the base of the crown by the adherent coloring matter; the colored portions are then ground down somewhat on an emery wheel, and this process is repeated until the entire surface of the base of the crown exposed to the pigment becomes uniformly coated. Whenever it is thought important to preserve the form of the porcelain crown unchanged, the operation may be reversed by coloring

the base of the latter and filing from the extremity of the fang until a perfect adjustment of the parts is secured.

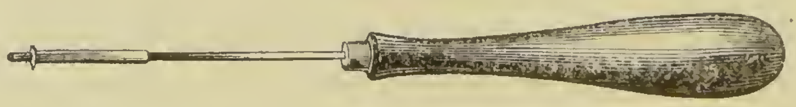
Another method, sometimes employed, may be adopted, and will secure an equally accurate bearing of the crown without subjecting the patient to the annoyance of repeated trials of the pivot tooth in the mouth. After having prepared the root in the manner already described, an impression of the root and contiguous teeth is taken, and from this a plaster model is obtained. The drilled cavity in the root will be indicated on the model by a corresponding depression; this may be extended into the body of the latter with an instrument fitting the orifice and held in the exact position as when enlarging the canal in the fang. The model is then varnished, and a pivot being temporarily attached to the crown, the base of the latter may be ground, with or without the use of coloring matter applied to the model, until the articulating surfaces close uniformly, and the crown occupies the required position indicated by the adjoining teeth represented on the model. If the impression is correct, and the manipulations are accurately conducted, a pivot tooth prepared in this manner will be found to fit the root and occupy a proper position in the circle with but little, if any, additional filing or grinding.

Attaching the Crown by means of Wood Pivots.—The usual method of fixing artificial crowns to the roots of teeth is by means of pivots of wood. Thoroughly seasoned white hickory of small growth, fine grained, and straight, compact fibers, is esteemed the best for the purpose. This substance is often used in its natural condition, but it will be much improved, both in respect to strength and durability, if previously well condensed by forcing it through the holes of an ordinary draw-plate, or, what is better, through apertures of various sizes formed with smooth bevelled edges in a piece of ivory, steel, or porcelain of sufficient thickness. Cylinders of wood of uniform thickness throughout are most conveniently formed by splitting the timber into rods five or six

inches in length, and from one-eighth to a quarter of an inch in diameter, trimming them with suitable instruments to a size one-third larger than required when condensed, and then passing them through the holes of a draw-plate, on the side where they form a cutting edge, commencing with the larger and passing to those of diminished calibre, until a cylinder of the size mentioned is obtained. These are then compressed in the manner before mentioned. When the draw-plate is used to compress the pivot, the latter should be passed through from the side opposite to the one used in forming the pivot.

One end of the pivot, dressed to the proper size, is made to fit accurately the hole in the crown, care being taken not to fracture the latter when forcing the pivot into place. The depth of the enlarged opening in the root will determine the length to be given to the end of the pivot projecting from the crown, and the former may be readily determined by means of a gauge, (Fig. 35,) consisting of a rod of wire of a

Fig. 35.



size to enter freely the canal in the root, with a movable slide, to the end of which is attached a circular collar or flange. The end of the wire being pressed to the bottom of the canal, the flange, resting against the end of the root, will force the slide back upon the rod, and thus indicate with certainty the depth of the canal. The pivot being cut off at a point distant from the crown equal to the length of the uncovered end of the wire, is then dressed to the size of the orifice in the root. The pivot should be accurately fitted to the canal in the fang, but not so tightly as to require any greater force in adjusting the crown to the root than may be readily applied with the fingers. A pivot thus easily applied, will, when enlarged by the absorption of fluids, be so firmly

retained as to render its removal difficult; and even when moisture is excluded, adequate stability will be imparted to the attachment, provided sufficient depth is given to the cavity in the fang.

Before adjusting the crown permanently, the pivot may be wrapt with one or two thicknesses of gold foil, and a thin layer of the same may also be placed between the crown and root. This is done with a view of protecting the pivot and inner walls of the fang from the action of fluids of the mouth. Other and more plastic substances, which are impermeable and not soluble in the secretions of the mouth, are sometimes interposed between the root and crown, as Hill's stopping, collodion, mastic dissolved in ether, &c. The following expedient recommended by Dr. S. D. Muse,* will answer the same purpose perfectly, but as it involves the use of "amalgam," it may be regarded as, in some degree, objectionable. The root being prepared in the ordinary way for the reception of a pivot, the central portion of its articulating surface is counter-sunk to the depth of half a line, leaving but a thin border on the outside to support the crown. The countersink is made with a bur drill, like that represented in Fig. 36. A pivot previously fitted to the root and crown, and of

Fig. 36.

the required length when the latter is adjusted to the root, is then fitted to the canal in the fang, when the excavation around the pivot is packed with carefully prepared amalgam in sufficient quantities to completely fill the counter-sink. The crown is now applied to the pivot projecting from the root and pressed firmly to its place, the amalgam, as an impermeable cement, luting the joint perfectly.

It not unfrequently happens that considerable enlargement exists at the orifice of the canal, as the result of decay, and

* Dental Register of the West, vol. vi. p. 154.

which, if not filled, will not only render the attachment of the crown insecure, but form a chamber for the accumulation of the secretions of the mouth and other substances, which decomposing, will render the substitute, in time, exceedingly offensive and pernicious in the mouth. In such cases it will be difficult to conform a wooden pivot accurately to the cavity, but the decayed portion and enlarged canal of the root may first be filled compactly with gold, and a central passage made through this with a drill for the admission of a pivot; or, in lieu of this, a highly polished and uniformly cylindrical steel wire of the same size as the crown-pivot, may be introduced into the prepared canal of the root and gold packed around it and into the excavation in the end of the root even with the surface of the latter; after which the steel wire is carefully withdrawn. In either of the above cases, the gold should be securely fixed in place by forming small pits, or transverse grooves, in the walls of the fangs.

Another method is to apply to the base of the crown, and round the pivot, a sufficient quantity of Hill's stopping, or other analogous material to fill perfectly the carious excavation; this is then warmed until sufficiently plastic, by passing it through the flame of a spirit lamp, when it is applied to the root and pressed up with sufficient force to expel any excess of material.

Pivots of Metal and Wood.—Pivots are sometimes formed of gold wire encased in wood. These impart additional strength to the attachment, and at the same time enable the operator to change the direction of the crown by bending the pivot whenever the root stands irregularly in the arch. A hole, somewhat smaller than that in the fang, is drilled into a block of pivot wood, and into this is forced a gold wire—that formed of gold and platinum being the best, as it possesses greater stiffness and elasticity. The wood is then dressed down to a size a little larger than the canal in the root, and then compressed. One end being fitted to the hole in the crown, the projecting portion of the pivot, cut to the

proper length, is trimmed to fit the opening in the root and applied in the manner before described.

Another method is to close the hole in the crown with a cylinder of pivot wood; trim it even with the base of the crown; perforate its centre with a drill; and introduce into this one end of the wire, the surface of which is cut up into small barbs, or otherwise roughened to prevent it from drawing. A similar piece of wood is fitted to the orifice in the fang, and trimmed and drilled in like manner for the reception of the wire pivot—the latter being barbed and filed square to render it stationary when forced into place.

Metal Pivot.—The best and most approved method of attaching the crown to the root consists in adjusting a metallic pivot to a gold tube attached to the root in such a manner that the substitute may be readily applied and removed by the patient. The tube which lines the enlarged canal in the root is constructed and applied in the following manner. A thin strip of ordinary gold plate, No. 28 or 30, and five or six inches in length, is first bent round a polished, cylindrical steel wire, the size of the intended pivot; these are both drawn together through a draw-plate until the gold tube is accurately conformed to the steel rod. The wire is then withdrawn, and the joint or seam in the tube soldered; before doing which, however, the joint should be coated on the inside with a mixture of whiting, to prevent the solder from flowing in upon the inner walls of the tube. A fine thread is then cut with a screw-plate on the tube, and having introduced into the latter a piece of the steel wire on which the tube is formed, the tube is seized with pliers or a small hand-vice, and screwed gently and carefully into the fang. The steel wire is then withdrawn, and the protruding portion of the tube removed with a file, or cut off with a fine saw, like the one represented in Fig. 32.

Another method of fixing the tube securely in place, as recommended by Dr. F. H. Clark, consists in closing the lower end of it with a spherical-shaped cap, and attaching to

the centre of this a small screw, which passes into the canal of the root, the latter being sufficiently enlarged and "tapped" for the reception of the screw.

In either case, if the filed end of the root is hollowed out by decay, a collar or flange should be soldered to the end of the tube on which the crown rests; underneath and around which gold is packed, filling completely the carious excavation.

The metal pivot may be fastened to the crown in either of the following ways: 1. A gold pivot fitting the orifice in the crown loosely is placed either in the centre or to one side of the latter, as the case may require, and around this solder filings or scrap are packed, filling in perfectly between the pivot and crown; the latter, with its cutting edge down, is then partly imbedded in plaster, and sufficient heat applied to flow the solder. 2. The use of a platinum pivot has been suggested by Dr. Frank Fuller, in which case he recommends the employment of jewellers' "soft enamel" as the uniting medium. The pivot is adjusted to the crown in the same manner as just described, and the enamel closely packed with suitable instruments around the pivot; the pieces are then invested, and sufficient heat applied to fuse the enamel. The latter may be obtained from jewellers or by pulverizing fragments of an old watch face.

The pivot being permanently fixed to the crown, the projecting portion is cut to the proper length and dressed to fit accurately the hollow wire lining the fang, but not so tightly as to prevent it from being easily introduced and withdrawn with the fingers. To render the crown stationary when applied to the root, the pivot should be slightly flexed that it may press upon the walls of the tube when introduced; or a small bar may be soldered on one side and near the bottom of the tube, so that when the pivot is forced up it will be compressed between the bar and opposite side of the tube, the portion of the pivot facing the bar being somewhat flattened. By far the best method of giving permanence to the

pivot, however, is that recommended by Dr. Dwinelle, in which he directs one-half or more of the pivot to be split into two equal parts with a fine watch-spring saw. The surface is then cut up into numerous small barbs, opening downward, and the end of the pivot filed somewhat to a point, so that when the two sections are spread apart, it will readily enter the orifice in the fang (Fig. 37). Pivots so formed should be constructed of gold alloyed with sufficient platinum to render them stiff and elastic. The diverging sections of the pivot when pressed into the canal will be found to bear with sufficient force against the sides of the tube to retain the tooth securely in place, and, at the same time, enable the patient to remove it at any time for the purpose of cleansing the substitute.

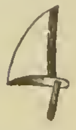
Fig. 37.

Pivot Plate.—It sometimes occurs that the root to be used occupies a position in the arch inconsistent with a harmonious arrangement of the tooth of replacement by the usual method of attaching an ordinary pivot-crown. Thus it may lie closely against one or other of the adjoining teeth, distant from the centre of the space; or it may have too great an anterior or posterior obliquity, or too great a lateral inclination; or, again, it may range with the other teeth with respect to its direction, but may occupy a position entirely within the circle; in either case it will be difficult or impracticable to give a proper relative position to the crown in the usual way. It is true, that any slight deviation from a just position or inclination of the fang may be compensated for by a corresponding inflection of the pivot, or by forming an abrupt angle to it where the crown and root unite, or by placing the pivot on one side of the hole in the crown; but when the irregularities spoken of exist to any considerable extent, it will become necessary to adjust a pivot-plate to the root, and attach to the base an ordinary plate tooth, to which any desired position may be assigned. The root, in such case, should always be provided with a gold tube, constructed

and applied in the manner already described, in order that the substitute may be easily removed and cleansed.

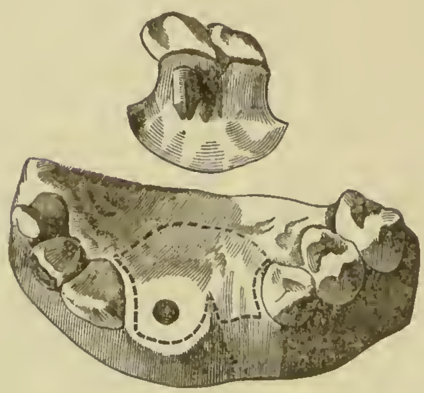
The form of plate, with pivot attached, for the replacement of a single tooth, is shown in Fig. 38. The method of constructing the plate and attaching the pivot will be fully described in a subsequent part of the work.

Fig. 38.



Whenever an edentated space exists contiguous to the root to be pivoted, the plate may be made to extend into it, and two or more teeth, as the case may be, mounted on the same base, provided the root, employed as a means of attachment, is strong, firmly socketed, and in a healthy condition. (Fig. 39.)

Fig. 39.



It will be sufficient to indicate, briefly, the means employed to favor the escape of purulent secretions through the fang, either where the discharge exists at the time of the operation, or is subsequently induced by it. It is customary to afford a passage for it by cutting a groove along the wall of the root or on the side of the pivot, through which pus is conducted from the bottom of the canal through the opening between the root and crown. A plan recommended many years ago by Dr. W. H. Elliot, consists in passing a small gold tube through the centre of the pivot, and in having an opening continuous with it through the crown of the artificial tooth. A modification of this practice was subsequently introduced by Dr. Coghlan, of Ireland, who substitutes, for the solid metal pivot, what he terms a *capillary tube*, consisting of a gold wire with its centre traversed by a very minute tube or canal, through which contained pus is permitted to escape from the apex of the root. In any case, where either of the above expedients is resorted to, the natu-

ral canal of the fang beyond the end of the pivot should, of course, be left open.

Since the publication of the first edition of this work, the author has made some applications of vulcanized rubber to the process of pivoting teeth, which are deemed sufficiently practicable and important to justify, in this connection, a description of the methods employed.

Substitution of Rubber for Wood Pivot.—Take small gold wire (alloyed with platinum), say about the dimensions of a medium sized knitting needle, or about one-third the diameter of the enlarged opening in the root, encase closely in a single layer of rubber, and vulcanize, but not so hard but that it shall possess some degree of flexibility, to admit of any necessary slight change in the direction of the pivot when permanently adjusting the crown. The relative advantages of the rubber pivot traversed with wire are obvious. It is wholly impervious to the fluids of the mouth,—it will present greater resistance to the forces applied in mastication than either the crown or root, and will sustain the pivot-crown immovably in its place. Wood readily absorbs and becomes thoroughly saturated with the secretions, and it is chiefly from this source that the offensive odor so frequently associated with pivot teeth arises. Besides, wood being flexible, its fibres are soon broken up or detached by the mobility of the crown, whose base is seldom accurately fitted to the root, thus necessitating a frequent renewal of the pivot.

Wired Rubber Pivot, with Rubber Base.—The object of this method is to secure a faultless adaptation of the base of the crown to the filed extremity of the root, and by interposing one or two thicknesses of gold foil, to render the joint impervious to the fluids of the mouth. Having prepared the root in the ordinary manner, select and fit the pivot-crown to the vacuity, leaving something of a space posteriorly between the base of the crown and the root. Fit a wood pivot to the enlarged opening in the root, accurately, but in

such manner that it may be easily withdrawn—the end projecting from the root should be trimmed down to say half the diameter of the hole in the crown, so that when the latter is applied in the manner to be mentioned directly, some margin will be left, admitting of a proper adjustment of the crown when applied to the space. With the wood pivot in the root, fill the hole in the crown with stiffened wax, warm the pivot crown sufficiently to soften the wax, and apply it to the root in the desired position with respect to the other teeth. When the wax has hardened somewhat, withdraw the crown carefully on a line with the pivot, bringing the latter with it; then add sufficient softened wax to the base of the crown to fill in the gap or space between the crown and root; replace the tooth with the pivot attached, and press up until the crown again takes its proper position in the vacuity. By this means we get an *impression* of the filed extremity of the root, and at the same time secure an accurate relation of all the parts. The crown and pivot are then carefully removed. Now, take plaster and pour a small quantity on a piece of paper or card and sink the pivot into it until the surface of the wax at the base of the crown rests upon the plaster, and then build the latter up upon the front part of the crown to the cutting edge, thus forming a shallow bed for its anterior face. When the plaster has hardened, warm the model to soften the wax, and then remove the crown and wax,—the pivot will be found remaining in the model, but which, if previously oiled, can be readily drawn. We have now in the model an accurate representation of the end of the root, the size and direction of the fang canal, and, when the crown is replaced in its shallow bed, also the space between the crown and root to be filled in with rubber. The hole in the model, corresponding with that in the root, should be enlarged somewhat, and this may be done with the same drill used in enlarging the orifice of the fang. After varnishing the hole in the model, pack in softened rubber until full, and insert into this the gold wire previously heated, one end

projecting a line or so. Next fill the hole in the crown with rubber, heat the crown, and press it down upon the model and over the gold wire until the crown goes accurately into the depression made for it in the model. Then pack softened rubber into the space between the base of the crown and the model until it is filled in compactly. The whole is then encased in plaster, confined in a flask and vulcanized. If the foregoing manipulations are carefully conducted, the crown will go to its place in the mouth with unerring accuracy, and by placing one or two thicknesses of gold foil between the rubber and root, the joint will be rendered impervious. There is still an additional advantage in this method. All are aware of the liability of a wood pivot drawing from the crown where the latter is short and the hole in it shallow. The rubber pivot, vulcanized in the crown, cannot be drawn from the shallowest cavity without fracturing the crown. This test was submitted to members of the Cincinnati Association, none of whom, holding the crown in the fingers, could withdraw the pivot with pliers, the hole being a fraction over a line in depth. The same tooth was subsequently fixed in a vice, and in drawing the pivot with pliers, the crown was fractured in the attempt. In very many cases this circumstance is of great value.

Canal of Fang lined with Rubber Tube for the reception of Gold Pivot Vulcanized into a Crown with a Rubber Base.—The manner of forming a rubber tube for the fang is exceedingly simple. Draw a wire of gold alloyed with platinum, say half the ordinary diameter of enlarged opening in the root, and from two to three inches in length; encase this in a single lamina of thin tin leaf to prevent the rubber from adhering to the wire, which will enable the latter to be readily withdrawn after induration of the gum. Then wrap the wire tightly in a single layer of rubber, encase in plaster and vulcanize; place the vulcanized tube in a vice, and withdraw the wire with pliers. Digest the tube in solution of muriatic acid to remove tin. The same wire is used for pivot,

and will enter the tube readily, but accurately. Dress down a portion of the tube to fit the orifice in the fang, and force the tube up with wire encased, and then remove the latter, and file off the tube to the end of the root. The tube may be fixed more securely in the fang by smearing its surface with a little thin osteoplastic material before introducing. The crown being fitted to the space, and the gold pivot placed in the tube with a line or more projecting, the hole in the crown is filled with wax, and applied to the base of the crown, and the same manipulations practiced to secure an impression of the filed extremity of the root, as previously described. Remove the crown, with wire pivot attached, carefully from the mouth, and imbed in plaster precisely in the manner as before related. In this case, however, after the crown is removed from the model, the wire pivot is allowed to remain attached to the model, when the hole in the crown is filled with rubber, the latter softened with heat, and the crown forced back into its place upon the model, the projecting end of the wire pivot penetrating the rubber in the crown. The interspace is then packed as before, the whole encased and vulcanized. In re-applying the tooth to the fang in the mouth, the pivot will be found to enter the tube too freely to give it the proper support,—the latter may be secured either by flexing the pivot upon itself slightly, or by splitting it part away with a fine watch-spring saw, and spreading the ends apart, as recommended by Dr. Dwinelle. By this method, the patient will be enabled to remove the crown at will, for the purpose of cleansing the parts, though if the crown can be secured in such manner that there shall be no movement of it, or change of relation with the root, under any force that may be applied to it, (a practicable thing with this method,) and the joint can be rendered perfectly impervious, it is preferable to make the crown stationary by fixing it immovably in the first instance.

Substitution of a Plate for a Pivot Tooth.—Line the canal with rubber tube as before. Adjust a plate tooth to the

space, and then solder on a gold backing. Place the wire pivot in the tube, with the end projecting. Hold the crown firmly to its position in the vacuity, and press softened wax or plaster around the end of the pivot and down upon the filed surface of the root and against the gold backing. Remove crown and pivot carefully, and imbed in plaster and sand; remove the wax or plaster, heat up and solder the pivot to the backing. Reapply to the mouth, press in softened wax posteriorly down upon the filed extremity of the root; remove carefully; imbed as before in plaster; remove wax, and pack softened rubber down upon the portion of the model representing the filed end of the root, around the pivot and against the gold backing, adding sufficient gum to enable you to dress it, when vulcanized, to the form of the adjoining natural organs.

If, after the operation of engrafting an artificial crown, inflammation of the peridental membrane and surrounding structures ensues, active measures should be immediatly instituted for its reduction. In a majority of cases, active suppurative inflammation is induced either by shutting up an habitual discharge from secreting surfaces at the apex of the root, or by a forcible injection of the air contained in the nerve canal into the sensitive tissues beyond the apex in the act of pressing up a tightly fitting pivot. These two circumstances, in conjunction, sometimes, with rough and unskillful manipulation, afford a rational explanation of the needless failures so common to this method, and enforce the necessity of first radically treating any existing disease in the appendages of the root, and of afterward filling to the apex before introducing a pivot. Where inflammation results from the injudicious application of the pivot as just stated, it will ordinarily be sufficient to remove the latter if timely application is made by the patient for relief; and it is important in all cases to instruct the latter in reference to the necessity of early attention to any disturbance that may accrue from the operation. In addition to the withdrawal of

the pivot, it will be prudent at the same time to direct the application of some active counter-irritant to the gum directly over the affected root, until resolution, if practicable, is effected. The topical remedies will sometimes be rendered more effective, especially when the local trouble is associated with an inflammatory diathesis or febrile condition of the system, by such constitutional treatment as will tend to equalize or diminish the force of the circulation, as general blood-letting, emetics, saline aperients, nauseants, arterial sedatives, &c.

CHAPTER VI.

PARTIAL DENTURES RETAINED IN THE MOUTH BY MEANS OF CLASPS ATTACHED TO THE NATURAL TEETH.

Remarks on the Use of Clasps.—Clasps, or metallic bands, have been long and very generally employed as a means of retaining parts of sets of teeth in the mouth, and are still almost exclusively used for that purpose by a large class of practitioners. When these appliances are skillfully adjusted, and all the conditions pertaining to the mouth and remaining natural teeth are favorable to their application, they afford a certain, permanent and satisfactory means of supporting partial dentures, and may be employed, under such circumstances, with comparative safety to the natural organs. When it is remembered, however, that in a lamentably large proportion of cases, clasps are carelessly or unskillfully formed and fitted to the teeth; that the organs of support are often indiscriminately selected, and are neither adapted in form, situation or structure for such uses; and that they are frequently diseased and insecurely attached to the jaw, or are mutilated for the reception of clasps; we can readily understand to what unlimited extent this method is subject to abuses. In fact, no other special process in mechanical practice has been so fruitful of evil as that under consideration, and the opprobrium which but too justly attaches to it in professional as well as popular estimation, is chargeable more properly to bad faith and unskillfulness on the part of the operator, and to want of attention in respect to the cleanliness of the substitute and the organs of the mouth on the part of the patient, than to any inherent unsuitableness of the method itself. Nevertheless, it must be admitted that,

under the most favorable circumstances, the teeth clasped are not wholly exempt from liability to injury, and this circumstance in itself renders it the more imperative that the process should be surrounded by all the safeguards that skill and ingenuity can devise.

The opinion, at one time current, that the injury inflicted upon the teeth by clasps was mainly the result of mechanical action, has given place to the more defensible view that the causes concerned in its production are chiefly of chemical origin. Thus, the secretions of the mouth with particles of alimentary and other substances being retained between the clasp and tooth for a sufficient period of time, and exposed to the favoring conditions of warmth and immobility, suffer a process of putrefactive decomposition by which acids are eliminated, and which, in their nascent state, act with perceptible energy upon the bone constituents of the tooth, producing decay. The rapidity and extent of this action will depend much upon the nature and quantity of the acids liberated; the structural characteristics and vital resistance of the teeth; the mechanical execution, adaptation, and composition of the plate; and the personal habits of the patient with respect to cleanliness.

The most usual seat of decay in these cases is at the neck of the tooth where the enamel is thinest, and is sometimes limited to a circumscribed spot, but oftener extends on a line with the gum involving nearly or quite all of that part of the neck of the tooth embraced by the clasp. At first the enamel becomes bleached and softened as though macerated, and is ordinarily very sensitive to both chemical and mechanical irritants. With a continuance of the cause, the superficial portions of the affected parts become more and more thoroughly disintegrated, and sooner or later assume the open form and characteristics of ordinary decay. If, as was formerly supposed, decay or solution of tooth-bone in these cases resulted from mechanical attrition, or wearing away of the enamel, the injury would be inflicted at points

distant from the neck of the tooth, where the clasp lies in more direct and immediate contact with the protuberant portions of the crown; but we find that decay, from this cause, is not only of infrequent occurrence at such points, but, on the contrary, the enamel here is frequently found condensed and polished by the mechanical action of the clasp. Certain conditions of the plate and clasp undoubtedly favor chemical action and accelerate the destruction of the tooth; as where the clasp bears unequally with sharp and unfinished edges upon the tooth, or where the base is faulty in its adaptation to the mouth, admitting by its mobility, of irregular traction or pressure upon the organs of support. Whenever the artificial appliance is thus unskillfully constructed and applied, and free interspaces are furnished for the lodgment and retention of particles of food, and the teeth clasped are defective in structure, and we have conjoined with these an utter disregard of cleanliness in respect to the substitute and remaining natural teeth, the destruction of the latter is certain, rapid, and generally irretrievable.

The Teeth to which it is most proper to attach Clasps.—The utility, comfort, and appearance of a partial set of artificial teeth in the mouth, will depend much upon the fitness of the natural organs selected for the purpose of support. "A clasp," says Professor Harris, "should never be applied to a loose tooth, or to one situated in a diseased socket, or which is so much affected by caries as to render its perfect restoration and permanent preservation impracticable, and when none but such can be had, the proper course to pursue is to extract every tooth in the jaw, and replace the loss of the whole with an entire upper set. The application of clasps to diseased or loose teeth, always aggravates the morbid conditions of the parts, and causes the substitute which they sustain, to become a source of annoyance to the patient. Besides, such teeth can be retained in the mouth only for a short time, and when they give way, the artificial appliance

becomes useless, and even while it is worn, it is not held firmly in place, but is moved up and down by the action of the lips and tongue, so that its presence can hardly escape observation from the most careless observer."*

Teeth, also, that are too short to admit of sufficient breadth to the clasp to impart stability to the substitute, and those that stand very irregularly in the arch, rendering it difficult for the patient to apply and remove the appliance, are unsuitable as organs of support.

In respect to the individual classes of teeth, it may be observed that the incisors, both as regards form and situation, are inadmissible for clasping, and are, therefore never used for this purpose. The cuspidati, likewise, being placed conspicuously in the front part of the mouth, cannot be securely embraced without manifest exposure of the clasp; besides, the conical form of these teeth makes the use of a very slender clasp indispensable; hence, these teeth are rarely employed, and may only be used when, in the judgment of the operator, the necessities of the patient for the time being seem to require it.

Either the anterior or posterior molars, when sound and firm, offer, in respect to their general conformation and position in the arch, the most desirable and efficient support for parts of sets of teeth. The crowns of these teeth generally afford ample breadth to the clasp; have nearly parallel walls; and furnish, by the strength and immobility of their attachments to the jaw, the greatest security to the artificial appliance. The anterior molars are preferable where these are remaining in good condition, or are susceptible of being properly restored and preserved if diseased or carious.

Of the bicuspids, the posterior are to be selected, if practicable, as these better favor the concealment of the clasps; to effect which more perfectly, in the use of either the first or second bicuspids, it will be sufficient in many cases to embrace only the posterior half of the crown.

* Principles and Practice of Dental Surgery, p. 717.

The dentes sapientiæ, or wisdom teeth, will seldom admit of the application of clasps, as the crowns of these teeth are usually very short and cone-shaped, the walls converging abruptly from the gum; besides, the retractive forces applied to the anterior teeth of the substitute, would, on account of the increased leverage consequent upon the extension of the plate back to these teeth, tend either to disengage the clasps or produce displacement of the teeth to which they are applied.

In supplying the loss of one or more of the inferior incisors, the appliance should, as a general thing, be attached either to the anterior or posterior bicuspids, as these teeth stand more nearly vertical in the arch. In fixing partial lower dentures, it will be sufficient to simply provide against mobility of the base, as they are favored rather than opposed, as above, by gravitation. The replacement of the inferior teeth posterior to one or both bicuspids, however, are more frequently demanded; in which case it is customary to attach the clasps to the teeth immediately in front of and adjoining the vacuities on each side. It will not, however, be necessary to attach clasps in these cases whenever the edentated portions of the jaw present a distinctly scooped form, or marked concavity of outline, forming a kind of bed for the plate. If, on the other hand, the ridge falls back with a tolerably uniform inclination from the teeth in front, with no sufficient elevation at the base of the coronoid process, it may become necessary to provide against backward displacement of the substitute by attaching clasps, as before stated, to the teeth immediately in front. In any case, if the dentes sapientiæ remain, partial or stay clasps may be attached to each heel of the plate, and so adjusted as to rest against the anterior face of these teeth, obviating entirely the necessity of clasps in front.

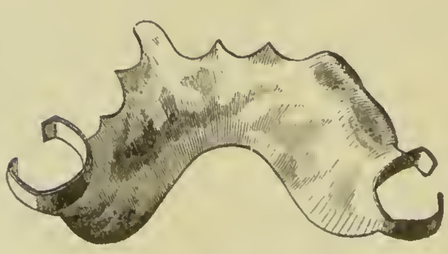
Separation of the Teeth, by Filing, for the Reception of Clasps.—The practice of separating the teeth with the file to provide for the application of clasps should always be

avoided if practicable, since the liability of the teeth thus denuded of enamel to decay is greatly increased under circumstances so favorable to their disintegration. In the case of young subjects, especially, where the teeth are but imperfectly consolidated, and in adults whose teeth are defectively organized, presenting but a feeble resistance to the disorganizing agents usually present in the mouth, the use of the file, for the purpose indicated, is eminently pernicious, and should never be resorted to until every other means of supporting the artificial appliance have been fairly and patiently tried.

Whenever a plain necessity for this operation exists, a careful examination of all the teeth, to which it is proper to apply clasps, should be made, and if decay is found upon their proximate surfaces, the separation should be made between the teeth so affected; and this circumstance should, in most cases, determine the selection, though the affected tooth or the one adjoining may not be esteemed, in other respects, the best for the purposes of support. If decay exists on the proximate surface of only one of the teeth to be separated, a safe-sided file should be employed, and the filing confined entirely to the carious tooth, leaving the enamel of the one adjoining unbroken. The cavity of decay should be well filled, and the filed surface thoroughly condensed and polished with a burnisher.

Modifications in the Form of Clasps.—1. *Plain Band.*—The most usual form of clasp is that shown in Fig. 40. It consists of a plain metallic band of greater or less width and thickness, and is made to embrace the larger portion of the circumference of the tooth. In respect to the general properties of metallic clasps, it may be said

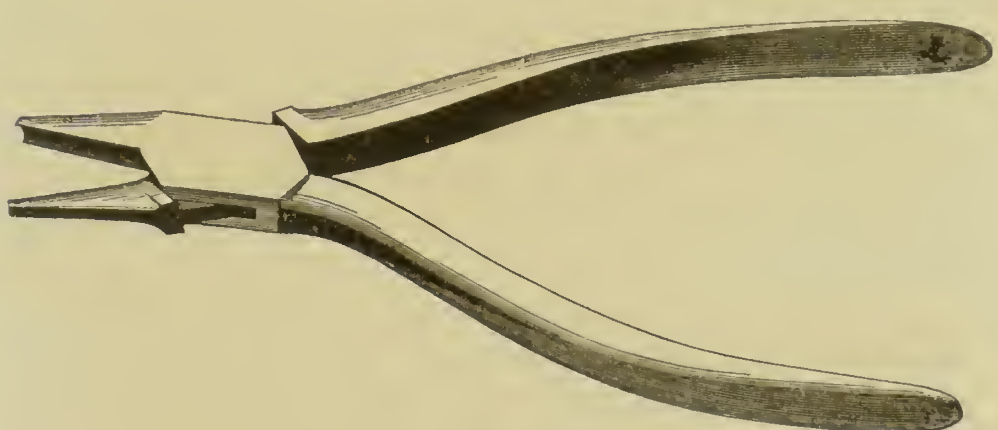
Fig. 40.



that they should be, as nearly as practicable, of the same

quality or fineness as the plate or base to which they are united; they should be heavy enough to impart adequate security to the attachment, say twice the thickness of the base, and exceeding this in some cases; and sufficiently elastic to embrace accurately the more contracted parts of the teeth after having been temporarily forced apart in passing over the enlarged portions of the crowns. In constructing a plain band or clasp, a strip of sheet lead or other pliable substance may first be fitted accurately to the plaster tooth, making it of the required width, and shaping the edge next the gum in conformity with the irregularities in the latter around the neck of the tooth; the exact counterpart of the pattern thus obtained is then cut from the plate to be used in the formation of the clasp. The strip thus obtained is then bent with round-nosed or grooved pliers, (Fig. 41,) until

FIG. 41.



conformed as perfectly as possible to every portion of the surface of the tooth embraced by it. This coaptation should be sufficiently accurate to exclude perfectly all solid substances from between the clasp and the tooth. A more accurate adaptation of the clasp may be secured in the following manner: First secure a pattern, as before described, and by this cut from a thin strip of platinum, say No. 30 or 32 of the gauge-plate, a band of the required size and form, and press or burnish it accurately to the form of the plaster

tooth. The soft and pliant condition of this metal will admit of its being easily adapted to any irregularities upon the lateral walls of the tooth. The band thus molded to the tooth is then carefully removed from the model, or the mouth, if fitted to the tooth in the latter, and its central portion filled with a mixture of plaster and sand with a small metallic wire or bar passing through the centre to support it while soldering. The outer or exposed surface is then smeared with a mixture of borax, and small scraps or fragments of gold plate of equal fineness with the main plate, are placed at intervals and fused with the blow-pipe until diffused uniformly over the surface. Small pieces may be added from time to time, until the required thickness of the clasp is obtained. The piece should be heated uniformly throughout to induce an even flow of the gold over the exterior surface of the platinum ring. By this method a faultless adaptation of the clasp to the tooth may be secured, provided the form of the latter is correctly represented on the model. In all cases where the plain band is used, it should be made as broad as the tooth will admit of, as a clasp so formed gives greater stability to the plate, and does not endanger the tooth clasped in any greater degree than a narrow one.

2. *Standard Clasp.*—To guard more perfectly against the retention of vitiated secretions and particles of food around the neck of the tooth, a method of constructing clasps has been devised and introduced to the notice of the profession by Dr. C. W. Spalding; which, by leaving the cervical portion of the tooth in a great degree uncovered, permits the action of the tongue and the natural circulation of the fluids of the mouth to wash or cleanse that portion of the tooth most liable to be injuriously affected. In commenting on this method, Dr. S. remarks: "The writer has for many years been in the habit of employing *narrow* clasps for the purposes of support, making them of sufficient thickness to give the required strength, and attaching them to the plate by

means of standards, so arranged as to induce the removal of accumulations between the clasp and tooth, by the circulation of the saliva, (Fig. 42.) The use of one or more standards as a means of attachment, also provides, by a variation of their length, for the grasping of the tooth at any desired point. If the tooth is long, and particularly if it is at the same time bell-crowned, the point selected should be toward the grinding surface, as far from the gum as is found practicable. If the tooth is short and of such form that it can be successfully clasped at no other point than that near the gum, the plate should be cut away at least one or one and a half lines from the tooth, and standards introduced for the purpose of promoting circulation, by affording a free passage for the ingress and egress of fluids. These standards should also be *narrow* no wider than the clasp itself, and should constitute the only point of union between clasp and plate. Half-round wire will be found to be a very convenient article for making clasps. The particular *form* of the clasp is, however, immaterial, if it is both narrow and strong."*

Fig. 42.

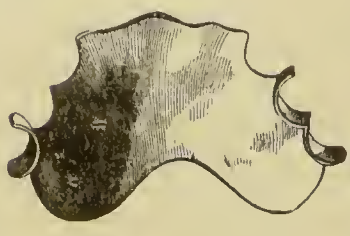
3. *Scalloped Clasp.*—Somewhat analogous in form to the clasp just described, and constructed with a similar design, is the one recommended by Dr. B. T. Whitney. A plain band of gold is fitted to the tooth in the manner first described, when that portion of it next the gum on the lingual side of the tooth is scalloped or cut away in the form of a semi-circle or arch, the ends of the clasp being in like manner narrowed sufficiently to relieve them from contact with the neck of the tooth. The intermediate points of the clasp which serve to unite the latter to the base may be two or more in number, and should be wide enough to impart adequate strength to

* American Dental Review, vol. i., p. 12.

the attachment. A clasp so formed and applied to the base will present very nearly the appearance of the standard clasp as represented in Fig. 42. Dr. W. recommends soldering but a single point at first, and then having tried the plate in the mouth and adjusted the clasp properly to the tooth, remove and solder the remaining point or points.

4. *Partial or Stay Clasp.*—This form of clasp, instead of embracing the tooth, is designed to steady or fix the substitute in place by simply resting against one side of the tooth to which it is applied. (Fig. 43.) They should be so connected to the plate that when pressed over the enlarged portions of the crowns of the teeth, they will spring readily into place and adapt themselves closely to the more contracted parts near the gum. In cases where there is no adequate opposing force to that exerted by the clasp, care should be taken that no more pressure is produced than is necessary to keep the substitute in place, as, without this precaution outward displacement of the teeth is liable to occur, and the appliance, losing its bearing upon the teeth, soon becomes loosened and insecure in the mouth. The result alluded to should be particularly guarded against in the case of young subjects whose teeth are easily moved by the application of very slight forces.

Fig. 43.



Modifications in the form of Plates for Partial Dentures supported in the Mouth by Clasps.—The particular form and dimensions of a plate, when clasps are used, will be mainly determined by the number and position of the teeth to be replaced, and by the location of the natural organs to which the clasps are attached. It will be sufficient in this place to indicate the leading forms as they relate to the substitution of the several classes of teeth. In supplying the loss of a superior central or lateral incisior, it will be sufficient in many cases to attach the plate to either a bicuspid or

molar on the same side, as in Fig. 44. If two or more of the front teeth, however, are to be replaced, it is better to extend the plate on each side of the palatal arch, and attach to a bicuspid or molar (Fig. 45); or to a bicuspid on one side, and a molar on the other; unless two firm and well-formed teeth on the same or the opposite side can be commanded, (Fig. 46,) while those upon the other could not be employed without a separation. In all cases where it is necessary to extend a narrow plate from the extreme front part of the

FIG. 44.

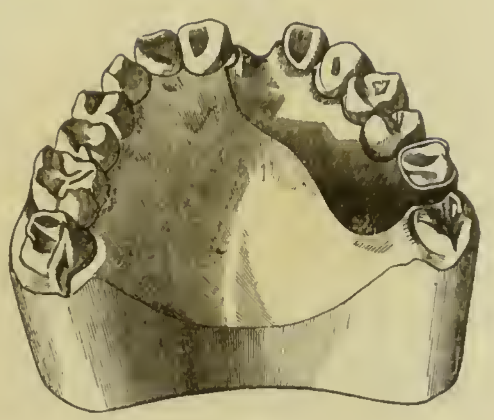


FIG. 45.

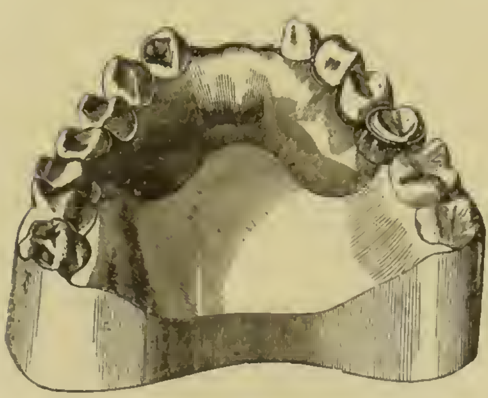
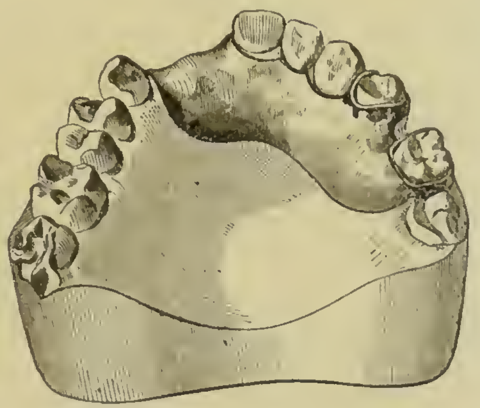


FIG. 46.



mouth to a single tooth situated posteriorly in the arch, the former should be strengthened by soldering a narrow rim of plate or half-round wire along the border next the teeth, and the clasp should, whenever practicable, pass in front of, and embrace, the anterior face of the tooth to which it is applied.

If an anterior bicuspid is to be replaced, the plate may be attached to the adjoining bicuspid; (Fig 47, right side,) or if both are absent, then to the first molar; (Fig. 47 left side,) or the clasp may embrace both of the latter if remaining

and no separation between them exists. Fig 48 represents the form of a plate supplying the loss of teeth at intervals;

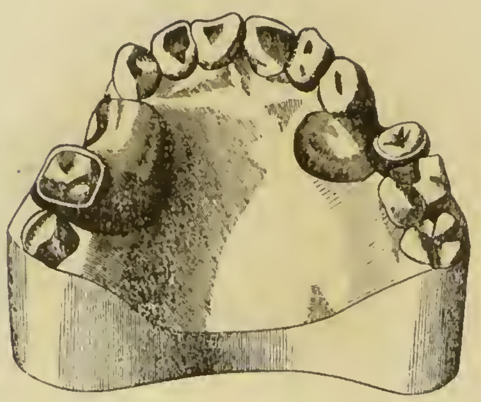


Fig. 47.

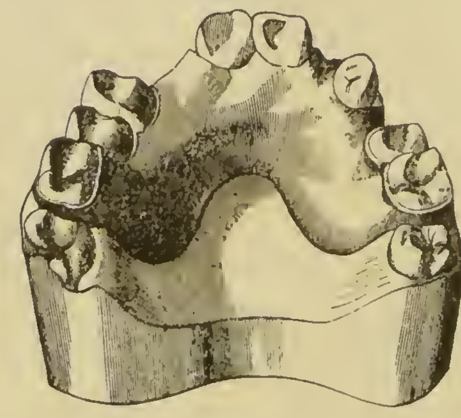


Fig. 48.

the clasp on one side embracing the posterior bicuspid in front and extending round the back part of the adjoining molar.

Fig. 49 represents the form of plate supplying the loss of the two bicuspids on one side, and the anterior bicuspid and molar on the opposite, the plate being attached to an anterior molar and second bicuspid. The antero-posterior extension of the plate, as exhibited in connection with the bicuspid tooth, greatly favors the stability of the substitute, and, provided the plate and clasp are accurately fitted to the parts, the support afforded by a bicuspid tooth under such circumstances is equivalent to that furnished by a firm and well formed molar clasped as shown on the opposite side. A base so supported may be made to sustain any number of teeth with the greatest security.

Either the anterior or posterior molars, if firm and securely attached to the jaw, will afford adequate support to a plate replacing all of the teeth anterior to them. (Fig. 50.) Even a single molar situated on either side of the arch, if similarly circumstanced, may be made to sustain, with tolerable firmness, a base supplying the loss of all the remaining teeth,—though, ordinarily, it is better to extract such a tooth and substitute an entire upper denture. In all cases,

where any considerable number of teeth anterior to those clasped are to be replaced, and a vacuity on the ridge exists

FIG. 49.

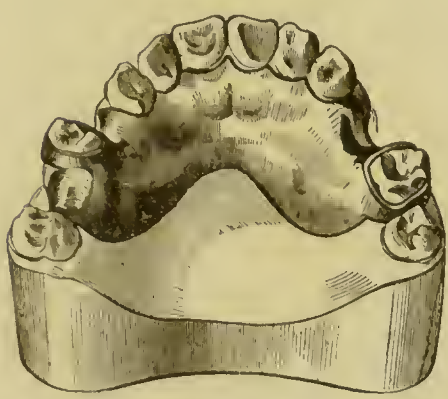


FIG. 50.

posterior to the latter, the plate should be extended back and overlap the ridge, (Fig. 51,) the latter affording a

FIG. 51.

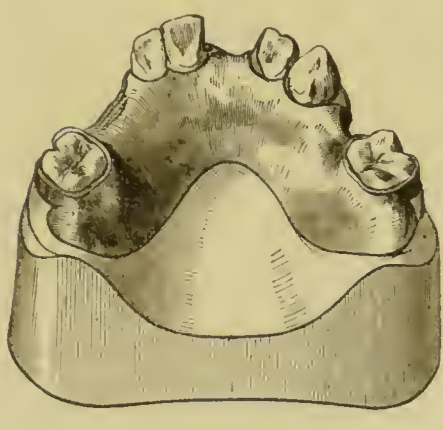
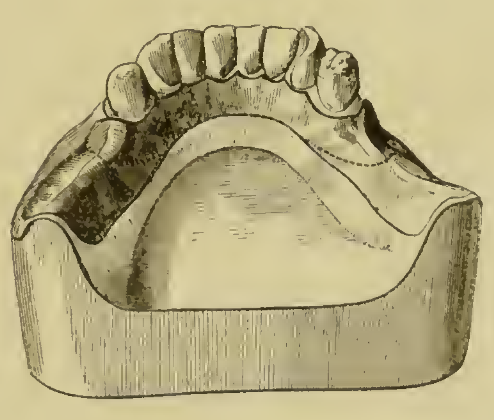


FIG. 52



counter-point of resistance when traction is made upon the anterior teeth, thus directing the forces applied more on a line with the long axes of the teeth that sustain the appliance.

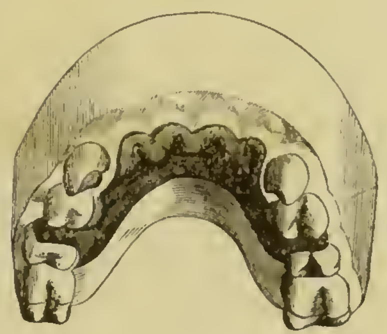
In supplying the loss of the inferior molars and bicuspids, or any number of these teeth, the form of plate represented in Fig. 52 is generally employed. The parts of the plate overlapping and resting upon the ridge behind, are connected with each other by a narrow strip of plate extending round

the ridge in front on the lingual side of the anterior teeth. This latter portion of the plate should be accurately swaged to the form of the gum on which it rests, and should be made narrow enough to avoid encroaching upon the reflected portion of mucous membrane, the glands beneath the tongue or the frænum linguæ. To avoid wounding these parts, and to allow them unobstructed play, it will be necessary to make this portion of the plate quite narrow; and as a single thickness of plate would not impart adequate strength, it is customary to double this connecting band—the duplicate band extending back to the lateral wings of the plate, and crossing them obliquely, as indicated by the dotted lines in Fig. 52. Additional strength will be given by doubling the entire plate, but this is not generally required. The outer borders of those portions of the plate overlapping the ridge may be turned up to the depth of from half a line to a line to form a groove or socket for the reception of the ends of gum teeth, or blocks, if such are used; while the inner margins should terminate in a rounded edge, extending from heel to heel of the plate, this form being given to it either by turning the edge over and filling in the groove with solder, or by soldering a narrow strip of plate or half-round wire along the border. The circumstances or conditions which make the use of clasps necessary in these cases, as well as those, also, which contra-indicate their employment, have already been noticed. The practice of extending a narrow band or wire from the sides of the plate round the outer border of the ridge in front of the anterior teeth, to prevent a backward displacement of the base, is liable to produce irritation and tenderness of the mucous membrane immediately over the roots of the anterior teeth, and should, therefore, never be resorted to, unless there are no teeth remaining to which clasps may be applied.

If the appliance is designed to restore the loss of teeth recently extracted, and where but little or no change has occurred from absorption of the parts, the portions of the plate

which pass in between the adjoining teeth should terminate a line or more within the outer circle of the remaining teeth; and where the space, if it happens in the front part of the mouth, admits of two or more teeth, the edges of the extended portion of plate should be scalloped in correspondence with the festoons of the gum, as seen in Fig. 53. In such cases, plain or plate teeth, by which is meant those which represent only the crowns of the natural organs, should be employed; these, resting on the edge of the plate, will overlap somewhat, with their anterior edges resting directly upon the gum in front, taking the place occupied by the crowns of the extracted teeth. On the other hand, if sufficient time has elapsed after the extraction of the teeth to permit the changes in the form of the ridge to occur incident to partial or complete absorption of the parts, and a greater or less concavity exists between and above the teeth on the outside of the jaw, the plate, where it passes into the interspace, should extend some distance over the border of the ridge.

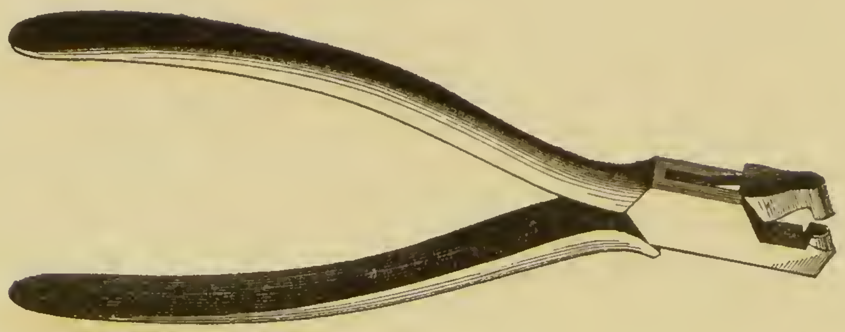
FIG 53



Swaging or Stamping the Plate.—Having determined upon the proper form and dimensions of the plate for any given case, its outlines may first be traced upon the model; from this an exact pattern in lead may be obtained, or the pattern may be sufficiently ample to partially overlap the cut extremities of the teeth when the latter are not represented upon the die, having been previously cut from the model. The outlines of the pattern are then traced upon the plate of gold or other metal to be used for the base. The redundant portions of plate are then cut away with plate shears and forceps, and the edges trimmed smooth with a file. A very convenient and almost indispensable instrument for cutting away the plate where it describes the palatal

curvatures of the teeth, is a plate forceps, as exhibited in Fig. 54.

Fig. 54.



The plate cut to the proper form is now placed upon the die and brought as nearly as possible into adaptation with a wooden or horn mallet; it is then placed between the die and counter, the latter resting on an anvil or other equally resisting surface, when the two metallic pieces are brought forcibly together with a few steady and well directed blows of a heavy hammer. Tilting of the die, resulting sometimes unavoidably from a one-sided blow, may be obviated by placing a cone-shaped piece of cast-iron, brass, or zinc over the die, the base of the cone resting on the back of the die; by this expedient the force of the blow is equalized and concentrated more directly over the die. The metallic swages should, at first be brought cautiously together, and should be separated after the first blow or two to enable the manipulator to detect and remedy any malposition of the plate before it becomes intractable from continued swaging. If, in the process of stamping, any portion of the plate is found cracking or parting, its further extension at that point may be prevented by flowing a little solder at the termination of the fissure. During the progress of swaging, the plate should be frequently annealed, which is done by bringing it to a full red heat under the blowpipe, or by placing it in the furnace; the plate is thus rendered more pliant and can be more readily

and perfectly forced into adaptation to the irregularities on the face of the die.

If, after somewhat protracted swaging, the plate is not conformed perfectly to the face of the die, another and unused counter should be substituted for that in use; and, indeed, it is better in all cases to have duplicate copies both of the die and counter in reserve with which to complete the swaging, inasmuch as more or less deformity of both swages unavoidably occurs before the plate is brought into very accurate coaptation with the die. The stamping conducted thus far, the plate may be applied to the plaster model, and if found too full at any points, it should be trimmed with a file to the exact dimensions required. The margins of the plate adjoining the necks of the teeth should be permitted either to lie closely to them, or should be cut away, leaving a space equal to a line or more between the plate and the teeth; for if but a very narrow line of uncovered gum remains at these points, injury to the parts immediately surrounding the necks of the teeth is more liable to occur from strangulation of the interposed gum than if the plate were further removed from the teeth or rested directly against them.

If the portion of plate which passes in between the remaining teeth is quite narrow, as where but a single tooth is to be supplied, it should be strengthened by wiring the edges or doubling the plate at such point. It is also advisable in many cases, in order to provide more perfectly against fracture or distortion of the base in mastication, to wire or double the entire border of the plate adjoining the necks of the teeth. Narrow bands of gold resting against the necks of the teeth, constructed and adjusted after the manner of stay clasps, are sometimes soldered to the edge of the plate next the teeth; but unless the substitute is frequently removed from the mouth and cleansed, as well, also, as the teeth to which they are applied, serious injury is likely to be inflicted upon the teeth implicated.

The edges of those parts of the plate occupying the vacui-

ties on the ridge should be filed thin to admit of a more accurate adaptation of the artificial with the natural gum, and should not, as before observed, ordinarily extend beyond the outer circle of the contiguous teeth, allowing the gum extremity of the artificial tooth to overlap and rest directly on the natural gum above. If, however, the concavity between and above the teeth on the external border of the ridge is considerable, the interdentinal portions of plate should overlap the border completely and underlie the porcelain gum.

Uniting the Plate and Clasps.—Having proceeded thus far in the operation, the plate and clasps should next be united to each other, and the utility and comfort of the appliance in the mouth, as well as the safety of the natural organs used for the purpose of support, will depend, in a great measure, upon the accurateness of the relation of the several parts of the appliance to the organs of the mouth; it being a matter of primary importance that the various parts of the substitute should be so adjusted to the remaining teeth,—especially those to which the clasps are applied,—and the ridge and palate, that it shall not, in any material degree, act as a retractor upon the organs of support, or furnish interspaces for the lodgment of food, while at the same time it should be so fitted as to be easily removed and applied by the patient.

The clasps having been fitted to the plaster teeth and the base swaged to the form of the palatal arch and ridge, the plate is placed in its proper position in the mouth and an impression in wax taken of the latter with the plate in place. The impression with the plate adhering, is then removed from the mouth, its surface oiled and a model obtained in the manner heretofore described. If, in separating the model and impression, the plate adheres to the latter, it should be detached and adjusted to the model and the clasps arranged upon the plaster teeth. The plate and clasps may now be bound to the model with annealed wire, and united to each

other with solder; but the better way is to attach them to each other temporarily, with adhesive wax, in the relation they occupy on the model, and then remove them carefully and imbed the clasps and palatal face of the plate in a mixture of nearly equal parts of plaster, sand and asbestos. Before uniting the two pieces, on the model with wax, however, the ends of the clasps should be straightened out or spread apart, in order that they may part readily from the plaster teeth, without, in any degree, changing their exact relation to the plate; in doing which, it should be observed that all parts of the clasps which are to be united to the plate should remain in close contact with the plaster teeth. After the plaster mixture, in which the plate and clasps are imbedded, has become sufficiently hard, the portions of wax which temporarily united the latter should be removed, and the surfaces of the clasps and plate, where they unite with each other, smeared with borax ground in water to the consistence of cream; small pieces of solder are then placed along the lines of contact, the investient heated in the furnace until the plate acquires a full red heat, when it is removed, placed upon a suitable holder, and the solder fused with the blowpipe.

Whenever the form and inclination of the teeth to be clasped are not fairly represented on the model, owing to dragging or displacement of the wax in withdrawing the impression, the difficulties of securing a proper relative adjustment of the several parts of the appliance will be increased; but either of the following methods, if carefully and accurately manipulated, will secure accurate results.

1. Gutta percha may be substituted for wax when taking an impression with the plate in the mouth. With the proper use of this material, the exact form and inclination of the teeth will be preserved; and when employed, it should be filled in with plaster for the model immediately after removing it from the mouth. The subsequent steps in the operation are precisely similar to those described when wax is used.

2. Another method is to adjust the clasps and plate to the parts in the mouth, attach them temporarily in their proper relation, and remove, invest, and solder in the usual way. This may be accomplished in the following manner: First spread apart the ends of the clasp somewhat to permit it to be easily removed from the tooth; place this upon the tooth in the mouth to be clasped; then adjust the plate in the mouth, and attach the two to each other by pressing a piece of stiff, adhesive wax in against the clasp and plate where they unite; harden the wax by placing against it, for a few minutes, the end of a napkin moist with cold water; then remove the plate and clasp carefully from the mouth, and invest and solder as before. The plate, with one clasp permanently attached, is now placed back in the mouth, and the second clasp adjusted to the tooth on the opposite side in the manner before alluded to; this is then temporarily fastened to the plate and otherwise treated in like manner as the one first described. If the teeth to be clasped are favorably formed and regularly arranged in the arch, both clasps may, at the same time, be temporarily attached to the plate in the first instance; if not, it will be impracticable to remove them from the teeth without disturbing the wax and changing their relation to the base and the teeth clasped. The additional labor and consumption of time incident to a separate attachment of the clasps, will, in proportion as they secure better results, amply reward the operator for his pains-taking.

Plaster is sometimes substituted for wax in this process; in which case it is introduced into the mouth on a small piece of wax or sheet lead and pressed gently against the uniting portions of the plate and clasp, and allowed to remain until sufficiently hard. Any superfluous portions around the tooth that may hinder the easy removal of the clasp should now be cut away, when the pieces so attached to each other are removed from the mouth. A separation of the plaster from the clasp or plate, or both, may occur when

removing the latter; in this case, the several parts may be readily and accurately adjusted to each other again in their exact relation when out of the mouth; as the latter will be plainly indicated by the impression made by the plate and clasp in the plaster. Being re-adjusted, they may be further secured by sticking them together with a little softened wax, when they are invested, the temporary fastenings of plaster removed, and the pieces united by soldering. The use of plaster in these cases is due to Dr. Lester Noble, and unquestionably possesses many advantages over wax for the purpose, as the latter is liable even with the most skillful manipulation, to become displaced in removing it from the mouth; and this change, when it occurs, not being indicated by inspection of the wax, is incapable of timely correction.

3. Still another method is that contrived by Dr. Fogle, and described by Dr. Cushman in the tenth volume of the American Journal of Dental Science. It consists in securing the proper relation of the clasps to the teeth in the mouth by the use, in the first instance, of what are termed "temporary fastenings." The plate and clasps are first applied to the model, and are then connected by a narrow strip of plate or piece of wire bent in the form of a bow, the concavity facing the model, one end of which is soldered to the palatal side of the clasp, and the other to a contiguous point upon the plate. The pieces thus temporarily united are removed from the model and adjusted to the parts in the mouth. If the position of the clasps is found in any respect faulty, they can be easily and accurately adapted to the walls of the teeth by bending or twisting the connecting strip in any desired direction with pliers or other instruments suitable for the purpose. This accomplished, the plate and clasps are removed, and the operation of permanently uniting the clasps to the plate performed in the usual manner.

CHAPTER VII.

PARTIAL DENTURES SUPPORTED IN THE MOUTH BY MEANS OF CYLINDERS OF WOOD ATTACHED TO TUBED PLATES.

THE following description of a method of supporting partial sets of teeth in the mouth by means of wood cylinders attached to the plate is copied from an article contributed by Dr. W. M. Hunter to the fourth volume of the American Journal of Dental Science. The same principle had long been made available in Europe in attaching artificial substitutes constructed of the hippopotamus ivory, but the credit of its application to metallic plates is alike due to Drs. Hunter and Charles Stokes of London.

"After swaging, the plate, as usual, is tried in the mouth, and an accurate impression of the teeth to be used, is taken over the plate, as recommended by Dr. Arthur, in the American Journal, which will show the exact position of the tooth in its relation to the plate; after which the edge of the plate surrounding the teeth to be made use of, should be doubled or wired, when the tubes may be soldered at their proper points, taking care never to apply pressure to one side of a tooth without some means of counteracting the effect; the means being either a *sufficient number* of natural teeth contiguous to the tooth to be used, a counter tube, an arm of metal, or an artificial tooth, depending entirely upon the nature of the case.

"At times, it is well to tube but one side of the plate and clasp the other; in cases where the crown of the tooth is much larger than the neck, a beautiful application may be thus made.

"The tubes should be from one-eighth of an inch to one

line in diameter, and should be filled with whiting before applying heat, to prevent them from filling with solder at the time of soldering to the plate. They should be placed upon the plate so carefully, that the mouth of the tube will come in contact with the natural tooth, as it is desirable to have the wood protrude but very slightly beyond the orifice.

"When it can be properly done, the tubes are soldered at the same time the teeth are, as it saves much trouble in fitting; it cannot, however, be very well done where it is designed to fit a tooth over a tube, but can very readily be done where the tube is designed to fill the angle caused by the meeting of the stay and plate, in the incisors and canine teeth, and where a canine is used for a bicuspid, building over the tube with metal to form the inner cusp."

The accompanying cuts show clearly the form and application of the tubes referred to. In Fig. 55, showing on one side but a single tube, the counter-force is obtained by the artificial tooth which rests against the anterior face of the one to which the wood cylinder is applied. Fig. 56 exhibits

FIG 55.

FIG. 56.

tubes arranged on one side, and a clasp on the other; and shows the substitution of a canine for a bicuspid, with an inner cusp built up over the tube, practically converting a cuspid into a bicuspid tooth.

In commenting on the application of this principle to partial sets of teeth, Dr. H. remarks: "The advantages in many cases must be apparent to the thinking dentist, but, perhaps, it might not be amiss to enumerate a few.

"The fixture is held in place with greater firmness than by means of clasps.

"In some instances where I have used clasps, I have also used the tube in combination, to give stability for masticating purposes.

"The injury to the natural teeth must be much less, owing to the smaller amount of surface in contact.

"If decay should take place, it would require but an ordinary filling to restore the tooth.

"It prevents that peculiarly disagreeable sensation experienced, particularly in fruit season, upon removing and replacing artificial teeth.

"After having tested it for more than a year, I am satisfied that it greatly lessens the chances of decay in those cases where it can be applied, and I have removed the clasps in some old cases with great satisfaction to my patients."

CHAPTER VIII.

PARTIAL DENTURES SUPPORTED IN THE MOUTH BY PIVOTING THE PLATE TO THE ROOTS OF THE NATURAL TEETH.

A limited number of teeth may be mounted on a plate pivoted to the roots of two or more of the front teeth; and provided the latter are firm, well formed, and in a healthy condition at the time of the operation, an appliance so adjusted may be worn by the patient with comparative comfort and efficiency for from five to eight years.

Ordinarily, the roots of the cuspidati afford the most secure means of attachment, and will furnish adequate support to a substitute supplying the loss of a part or all of the teeth anterior to the bicuspids, (Fig. 57,) and, in some cases, one or two of the latter on each side. The roots of the incisors, also, may be used, or one of the latter and a cuspidatus. In some cases the plate may be secured in the mouth by pivoting to a root on one side, or in front, and clasping to a tooth on the opposite side, (Fig. 58,) provided the crown of the latter and the pivot root stand nearly or quite parallel with each other, as any considerable deviation from this relation will render it difficult or impossible to apply and remove the substitute.

FIG. 57.

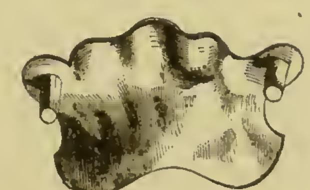
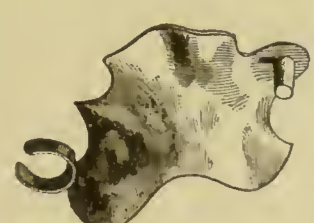


FIG. 58.



The roots of the teeth to be used as a means of support should be prepared in the manner described under the head of "Pivot teeth."

In all cases, the enlarged canal of the root should be provided with a gold tube, as this method is the only one which will protect the root from the mechanical action of the pivot, or permit a ready and frequent removal of the appliance for the purpose of cleansing it and the parts associated with it in the mouth.

The roots being prepared in the manner indicated, an impression of the mouth is taken, and with a die and counter obtained from a plaster model of the parts, a plate of the required form is swaged covering the filed extremities of the roots to be pivoted, and extending anteriorly very nearly or quite to the free margins of the gum in front. The plate at those points corresponding with the openings into the roots, is then perforated and enlarged sufficiently to admit of the passage of the metallic pivots; the form and position of the orifices in the roots being transferred to the metallic die, the corresponding depressions in the plate at these points when the latter is swaged, will serve as a sufficient guide in perforating the plate for the pivots. The plate is now applied to the mouth, and the metallic pivot, one-half longer than that ultimately required and formed to fit the tube accurately but not tightly, is passed through the opening in the plate and pressed to the bottom of the tube, leaving the surplus portion of the pivot projecting on the lingual side of the plate. The plate and pivot are now secured in this precise relation by imbedding the projecting portion of the latter and the parts of the plate immediately surrounding it, in a batter of plaster. When the plaster has hardened, the plate and pivot with the plaster attached, are removed in their undisturbed relation from the mouth. To preserve the several pieces *in situ* more perfectly, the projecting end of the pivot may be flexed, or a head formed on it with the file before applying the plaster; the pivot thus secured will bring all parts together if traction is made on the plate in the act of withdrawing the pivot.

The plate being removed from the mouth, its palatal por-

tion is imbedded in the plaster mixture, and when the latter is hard, the plaster is removed from around the pivot on the opposite side of the plate, and the pivot permanently united by flowing solder at its point of contact with the plate. The redundant portion of the pivot on the lingual side of the base is then cut and filed away even with the surface of the latter. If the manipulations have been accurately conducted, the plate and pivot, on being reapplied to the parts in the mouth, will be found to adapt themselves perfectly to the palatal arch and roots.

It is better, unless the roots to be pivoted stand nearly or quite parallel, to adjust and solder but a single pivot at a time, as but a very slight variation in the direction of the roots would render the withdrawal of both pivots at the same time difficult or impracticable without more or less change of relation. The same may be remarked of those cases where a clasp is used in conjunction with the pivot.

The most efficient method of rendering the appliance stationary when applied to the roots, and at the same time of enabling the patient to readily apply and remove it at will, is that recommended by Dr. Dwinelle, and described in a previous chapter.

Gold used for pivots in these cases should be alloyed with platinum, as that ordinarily employed for plate is too inelastic for the purpose.

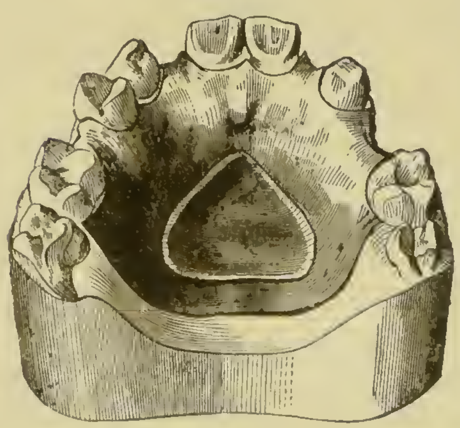
CHAPTER IX.

PARTIAL DENTURES SUPPORTED IN THE MOUTH BY ATMOSPHERIC PRESSURE.

THE method of attaching partial sets of teeth to the superior jaw by means of atmospheric pressure, is much more generally practiced now than formerly, and whenever the condition of the soft parts of the mouth, the general configuration of the palatal arch, and the antagonism or occlusion of the artificial with the natural teeth favor its adoption, there are good and sufficient reasons why it should be preferred, in all practicable cases, to either of the other methods heretofore described.

Modifications in the Form of the Base.—If vacuities exist at various points on the ridge, the plate on which the teeth of replacement are mounted, should be ample in its dimensions, covering nearly or quite all of the hard palate. The general form of the base where several teeth scattered throughout the arch are required, is shown in Fig. 59. In most cases, whether but one or a greater number of teeth are to be replaced, increased adherence and stability of the substitute will be better secured by permitting the plate to cover the larger portion of the roof of the mouth; though in cases that present the best form of the vault, a diminished surface may be given to the base with equally satisfactory results. In the substitution

FIG. 59.



of a single incisor, for example, it will frequently be sufficient to employ a very small plate, covering only a part of the anterior sloping wall of the palate. (Fig. 60.) In the

Fig. 60.

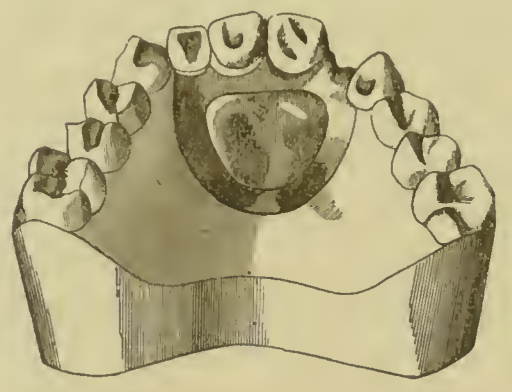


Fig. 61.

latter case, the plate used may be very thin, say No. 30 of the gauge; it will thus impede the movements of the tongue less, and may be swaged more accurately to the parts. If constructed with an air-chamber, the latter should be quite shallow.

A somewhat anomalous form of atmospheric pressure plate employed in the substitution of one or two bicuspid teeth on each side is described by Professor Taft,* the design of which is to secure, in such cases, increased stability of the substitute, while much of the palatal arch is left uncovered. It consists, as will be seen by reference to Fig. 61, of two lateral cavity-plates accurately adjusted to the sloping walls of the palate on each side, immediately adjoining and partly occupying the spaces to be supplied. These lateral plates may be made as large as a dime, or somewhat larger, and of an eliptical shape, if both bicuspids on the same side are to be replaced, and are connected with each other by a narrow band of gold plate, two lines or more in width, having an anterior curvature, and resting on the front wall of the palate, two or three lines behind the anterior teeth. The

* Dental Register of the West, vol. xiii. p. 112.

entire appliance may be constructed from a single piece of gold plate swaged accurately to the parts; or the lateral plates and connecting band may be separately swaged and secured in their proper relation to each other in the mouth with wax or plaster, when they are carefully removed, invested and soldered together; it should then be re-swaged to correct any change of relation that may have happened during the concluding manipulations. The liability of the plate to ride upon the central and raised portion of the palate, when pressure is made upon one side, throwing the plate off from the ridge on the other, as in the case of a base extending across the arch, is in a great degree obviated by the method just described.

Manner of Forming an Air-chamber.—Atmospheric pressure plates for partial cases are usually constructed with a central air-chamber; in which case, the part of the model representing the chamber may be formed in either of the ways mentioned in the chapter on "Plaster Models." The model prepared, the form of the plate to be used is first indicated thereon, and from this a pattern in sheet lead is obtained, which is placed on the plate of gold or other metal, and its outlines traced with a pointed instrument; the redundant portions are then cut away with plate shears and forceps. The plate is now placed on the die, and brought as nearly as possible into adaptation to the latter with the mallet and pliers; it is then interposed between the die and counter and swaged until it conforms perfectly to the face of the former; annealing the plate frequently to render it more pliant and manageable under the hammer. Unless the plate used is purer and thinner than is generally employed, or than is consistent with the required strength, it will fail to be forced perfectly into the groove around the chamber by the process of swaging alone; a more definite border, however, may be formed by forcing the plate in at this place with a small, smoothed-faced stamp, shaped to the angle of the groove, passing round the chamber and carefully forcing the

plate in with the stamp and a small hammer or mallet until a somewhat sharp and abrupt angle is obtained to the palatal edge of the chamber. After the chamber is as perfectly formed as possible in this way, the plate should be well annealed and again swaged to correct any partial deformity occasioned by stamping the chamber.

A still more perfectly defined angle may be given to the borders of the chamber in the following manner: After swaging the plate sufficiently to indicate the exact position and form of the chamber, the portion forming the latter should be separated from the main plate by completely dividing it with a small, sharp, chisel-shaped instrument, cutting on a line with the groove around the chamber until the latter is entirely separated. The cut portion of the main plate is then trimmed evenly with a file, being careful not to enlarge the opening more than is required to remove the irregularities of the edge formed in cutting. The plate, with its central portion removed, is then placed upon the die, when a separate piece of gold cut to the general form of a chamber, but somewhat larger than the opening in the main plate, is adjusted over the chamber and struck up with the plate until the overlapping portions of the central piece are forced down upon the plate around the margins of the chamber. It is not, however, always necessary to employ a separate piece of gold for the chamber, as the central portion cut from the plate in the first instance may be sufficiently enlarged for the purpose. This is accomplished by first flattening out the detached portion, annealing it, and then passing successive portions of its edges a sixteenth of an inch or more between the rollers, the latter being sufficiently approximated to produce a perceptible thinning of the margins. When the entire border of the chamber piece has been thus attenuated and extended, it will be found so much enlarged that when adjusted to the die and swaged in connection with the main plate, its borders will overlap and rest upon the margins of the opening in the base, as in the other case.

The portions of the plate and cut chamber lying in contact are now coated with borax and pieces of solder placed along the line of union on the lingual side of the plate, when the two pieces, being transferred to a bed of charcoal, are permanently united by flowing the solder with a blowpipe. Sufficient heat should be applied to induce an extension of the solder between the two portions of plate, filling up completely the gap between them to the edge of the orifice in the main plate, forming, at this point, a square and well defined angle to the margins of the chamber.

CHAPTER X.

METHOD OF OBTAINING AN ANTAGONIZING MODEL FOR PARTIAL DENTURES; SELECTING, ARRANGING, AND ANTAGONIZING THE TEETH; INVESTING, ADJUSTING STAYS, SOLDERING, ETC.

HAVING constructed the plate or base to be used as a support for partial sets of teeth in either of the ways described in the preceding chapters, it will be necessary, before arranging the teeth on the plate, to secure an accurate representation of all the remaining natural teeth of both jaws in plaster, preserving accurately the relation which these organs bear to each other in the mouth. This is effected by what is called an *antagonizing model,* and may be secured in the following manner.

A roll or strip of adhesive wax is first attached to the lingual border of the plate, and its adhesion secured by holding the opposite side of the plate for a moment over the flame of a spirit lamp. The wax used for articulating purposes should be harder and more tenacious than plain beeswax, and may be compounded from the following formula :

Beeswax, ...	1 pound
Gum mastich, ...	2 oz.
Spanish whiting, ...	1 oz.

The wax is first melted in a shallow vessel, and the mastich, finely pulverized, gradually added, and then the whiting, stirring constantly until thoroughly incorporated. The rim of wax being arranged on the plate, all superfluous portions overhanging the margins occupied by the remaining teeth are cut away ; the plate may then be placed on the model

and the wax again trimmed, leaving it somewhat fuller than the outer circle of the teeth, and from one to three lines longer than those immediately adjoining the spaces. The plate, with the wax attached, is then placed in its proper position in the mouth and the patient instructed to close the jaws naturally until the remaining teeth meet; one-third or more of the crowns of the opposing teeth opposite the spaces will thus be imbedded in the wax. A still fuller impression of the opposing teeth may be obtained, if desired, by pressing the edges of the wax down upon the crowns with the finger. If a series of anterior teeth are to be replaced, the mesial line of the mouth in front should be indicated upon the wax by drawing a line vertically across the latter to serve as a guide in the arrangement of the central incisors and adjoining teeth. The plate and wax are then carefully removed from the mouth and again placed upon the plaster model, the latter having been previously obtained from an impression of the parts with the plate in the mouth. The model is then placed on a slip of paper with the plate and wax upward, and the heel of the model extended from one to two inches posteriorly to form an articulating surface for the remaining portion of the antagonizing model. The added portion of plaster may be confined by a narrow strip of wax or sheet-lead extending back upon each side of the model, into which a batter of plaster is poured to the depth of half or three-fourths of an inch. When hard, the edges and upper surface of the added plaster should be trimmed smooth, and a crucial groove, or two or three conical-shaped holes, cut in the surface of the latter to secure a fixed and definite relation of the two parts of the model. The articulating surface is then varnished and oiled to prevent the next portion of plaster from adhering; the imprints of the teeth in the wax are also oiled. This portion of the antagonizing model, with the plate and wax attached, is exhibited in Fig. 62. The open space looking into the palatal vault should be closed with a sheet of softened wax to prevent the next portion of plaster from

flowing into the cavity underneath. A batter of plaster is now poured carefully upon the exposed surface of the wax, filling the imprints of the teeth perfectly, and extending back upon the heel of the model until it acquires a depth of half an inch or more. When sufficiently hard, the two sections of the model are separated; superfluous portions trimmed away; and the entire surface of both pieces glazed with varnish. The model complete, with the plate in place, and the wax (retained as a temporary support whilst adjusting the artificial teeth,) trimmed as required, are shown in Fig. 63, and if the manipulations have been accurate, this simple contrivance will exhibit all the parts represented in plaster in precisely the same relative position which they occupy in the mouth when the teeth are closed upon each other. It will be seen, by reference to Fig. 59, that only those teeth of the opposing jaw which present to the spaces, are represented in plaster, as these are all that are required in arranging the teeth of replacement.

FIG. 62.

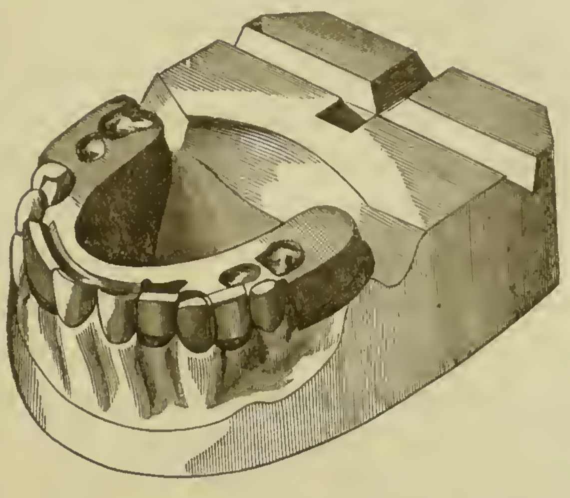
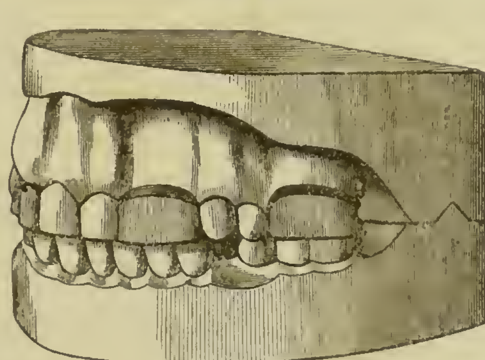


FIG. 63.

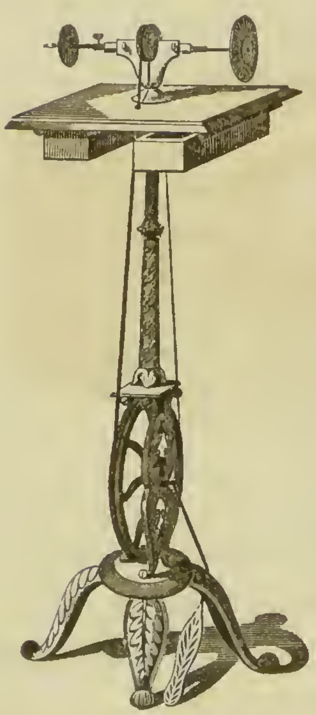


Selecting, Arranging, and Antagonizing the Teeth.—The teeth of replacement should harmonize, as nearly as possible, in size, configuration, and color, with those remaining in the mouth; and when selecting teeth for any given case, the operator should be provided with a sufficient number of sam-

ple teeth to meet every requirement, by comparison, in respect to the various tints or delicate shades of color characteristic of the natural teeth and gums. The required size and form of the artificial teeth may be determined with tolerable accuracy by a comparison with those on the plaster model, but the form or figure more certainly by a careful inspection of those in the mouth.

A greater or less change in the form of porcelain teeth will be required, in nearly all cases, in arranging and fitting them to the vacuities in the jaw; and this is more particularly so in those cases requiring the use of gum teeth. This alteration of form is effected by grinding away portions of the tooth upon an emery or corundum wheel, attached, as will be seen in Fig 64, to a foot-lathe. If the edentated portions of the ridge have suffered but little change of form by absorption, as where the teeth have been recently extracted, and plate teeth (those representing only the crowns of the natural organs) are used, the posterior portions of the base of the latter resting upon the margins of the plate will only require to be conformed to the irregularities on the surface of the base, grinding sufficiently to give to them the proper length and relative position, while their anterior cervical portion is permitted to overlap the edge of the plate and rest directly upon the gum in front on a line with the adjoining teeth. When, however, a considerable concavity exists in the ridge and external border, and single gum teeth are employed to restore the customary fullness and contour of the parts, the gum portion of the tooth should be ground away on its posterior face sufficiently to restore the circle of the gum on the external border of the alveolus, and from the

Fig. 64.



base of the tooth where it rests upon the plate, to admit of a proper relative position of the artificial crown; while those portions of the porcelain gum terminating at, and adjoining the remaining teeth, next the spaces, should be formed with a thin, retreating edge, where it laps upon the natural gum, giving to the parts, when the substitute is adjusted to the mouth, the appearance of an unbroken denture and á continuous gum. When the space to be supplied requires a series of two or more single gum teeth, the latter should be united to each other with the greatest care and exactness by grinding the proximate edges of the gum portions until the coaptation is such as to render the seams imperceptible in the mouth. In adjusting the porcelain teeth to the plate, the base of each tooth should be ground to rest as directly and uniformly on the plate as possible; for if thrown, in any degree, from the plate, the whole strain in mastication will come upon the platinum rivets, and, in a comparatively short time, the latter will either be entirely worn or cut off, or the artificial crown will be fractured on a line with the pins.

In antagonizing partial sets of teeth, the indications pointed out by the customary closure of the natural organs should be followed as nearly as the form and position of the opposing teeth will permit. A changed or abnormal relation of the teeth of both jaws, however, frequently renders it difficult to effect a satisfactory adjustment of the teeth of replacement. If, in the case of the bicuspids, for example, one or more teeth in the under jaw project into a vacuity above to the extent of one-third or more of its depth, a direct closure of the substituted organs upon these, in the ordinary manner, would be impracticable without a corresponding shortening of the porcelain teeth, enforcing, in such cases, an inharmonious arrangement, entirely inconsistent with the just requirements of the case. The difficulty cited, or any of the various modifications of it, may be overcome wholly or in part in one of two or three ways. If the teeth encroaching upon the opposite space are very loose, as is frequently the case with

those that have become elongated from the long-continued want of an adequate opposing force, or are hopelessly carious or otherwise diseased, they should be at once removed. If they remain firm and sound, and stand slightly within the circle of the teeth of the opposite jaw, or if they have somewhat of an inward inclination in the arch, the vacuity opposite may be filled with non-masticating teeth, as a canine, on the lingual side of which an antagonizing cusp of gold may be constructed, allowing the point of the cuspid to lap over upon the labial face of the encroaching tooth or teeth; or a bicuspid, manufactured for the purpose, with the inner cusp near the base of the tooth, may be used instead. Additional room may be provided, in such cases, for the overlapping portion by filing away from a corresponding point on the opposing tooth. If, however, taking the most impracticable case, the intruding teeth are sound and firm, and stand vertically in the arch, closing between the opposing teeth on a line with, or somewhat outside of, the outer circle of the latter, (the elongation of such teeth being rather relative than absolute, as where it results from a mechanical wearing away of the remaining antagonizing teeth and a corresponding approximation of the jaws,) the practitioner will be compelled either to submit to a mal-arrangement of the teeth of replacement by grinding away sufficiently from their grinding surfaces to permit an unobstructed closure of the natural organs, or decline the operation altogether.

The undue projection of the teeth of one jaw into a vacuity occurring in the one opposite more frequently happens, however, in connection with the loss of the superior incisors. In such cases, the points of the lower incisors very frequently encroach upon the circle of the upper teeth, so that when the artificial teeth are arranged above in correspondence with the circle of the adjoining teeth, and the jaws are approximated, the points of the inferior teeth will strike prematurely either upon the cutting edges of those above or will close upon their inner surfaces,—impeding thereby, or entirely

preventing, the occlusion of the teeth posterior to them. For such cases, thin teeth should be selected, and whenever necessary, the lower teeth may be filed away sufficiently, while those of replacement should, at the same time, be arranged as prominently as the circle will admit of. If these expedients fail, and a sufficient number of teeth posterior to the incisors require to be substituted in connection with the same appliance, it will be better, in cases not susceptible of satisfactory correction by the means already suggested, to change the bite by substituting an entirely new antagonism with the artificial teeth,—spreading the jaws sufficiently apart to relieve the artificial incisors in front.

In no case, except that last described, should the artificial teeth come in contact with the opposing teeth before the occlusion of the remaining natural organs when the jaws are closed. The contact of all the teeth of one jaw, artificial and natural, with those of the opposite, should either be simultaneous, or the natural teeth should be permitted to strike first.

In view of the difficulties which so frequently present themselves in connection with the arrangement of artificial teeth in partial cases, it may not be amiss to observe that, however essential to the natural and agreeable expression of the individual an exact and harmonious arrangement of the teeth of replacement may be, this requirement should, in some degree, be disregarded whenever the necessities of the patient, in respect to the comfort and utility of the appliance or the safety of the natural organs demand it;—to what extent appearances should be sacrificed to these considerations, will depend upon the peculiar exigencies of the case, and cannot, therefore, be specifically stated. On the other hand, it may be observed that, if a sufficient number of the natural teeth are remaining in both jaws to enable the patient to perform, with tolerable efficiency, the act of mastication, the mere utility of the substitute in regard to the performance of this function may be partly or wholly disregarded whenever there is sufficient reason to apprehend that the substi-

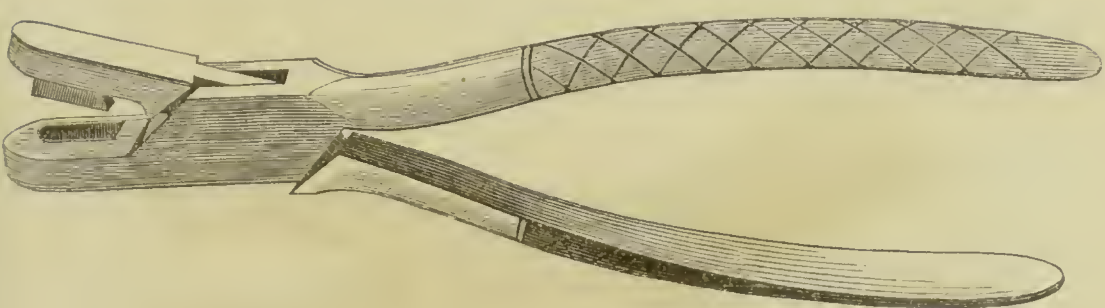
tuted organs cannot be antagonized with a view to the comminution of food without endangering the permanency and usefulness of the appliance by necessitating the application of forces unfavorably directed.

Investing, Adjusting Stays, Soldering and Finishing.—Having arranged and antagonized the teeth as accurately as possible on the plaster model, the piece should be placed in the mouth to detect and remedy any faultiness that may be found to exist either in the adaptation, position or antagonism of the artificial teeth. It is then removed and imbedded in a mixture of plaster, sand and asbestos, in the proportion of about two parts of the former and one part each of the latter. The body of the investient may be surrounded by a copper or sheet-iron band to prevent the plaster from breaking away whilst adjusting the stays or linings to the teeth. All parts of the plate and teeth, except the lingual side of the former and the backs of the latter, should be encased in plaster to the depth of half an inch or more, and when the latter is sufficiently hard, all traces of wax from the inside should be carefully detached with suitable instruments.

The piece is now ready for the adjustment of stays or backings, which, when permanently united by soldering to the base and teeth, are designed to sustain the latter in position. These supports are formed from plate somewhat thicker than that used for the base; a heavier and stronger stay being necessary when they are not united laterally, as when plate teeth are used. If, however, single gum or block teeth are employed, and the stays are joined, forming a continuous band, plate one-half thicker than that used for the base will, ordinarily, impart adequate security to the attachment. A plain strip, corresponding in width with the tooth to be lined, is cut, and the end resting on the main plate conformed accurately with the file to the irregularities on the surface of the latter, and in such a manner as to permit the strip to take the direction of the tooth. The general form of the stay may, in the first place, be obtained by cutting a strip from a piece of gold with a pair of plate forceps.

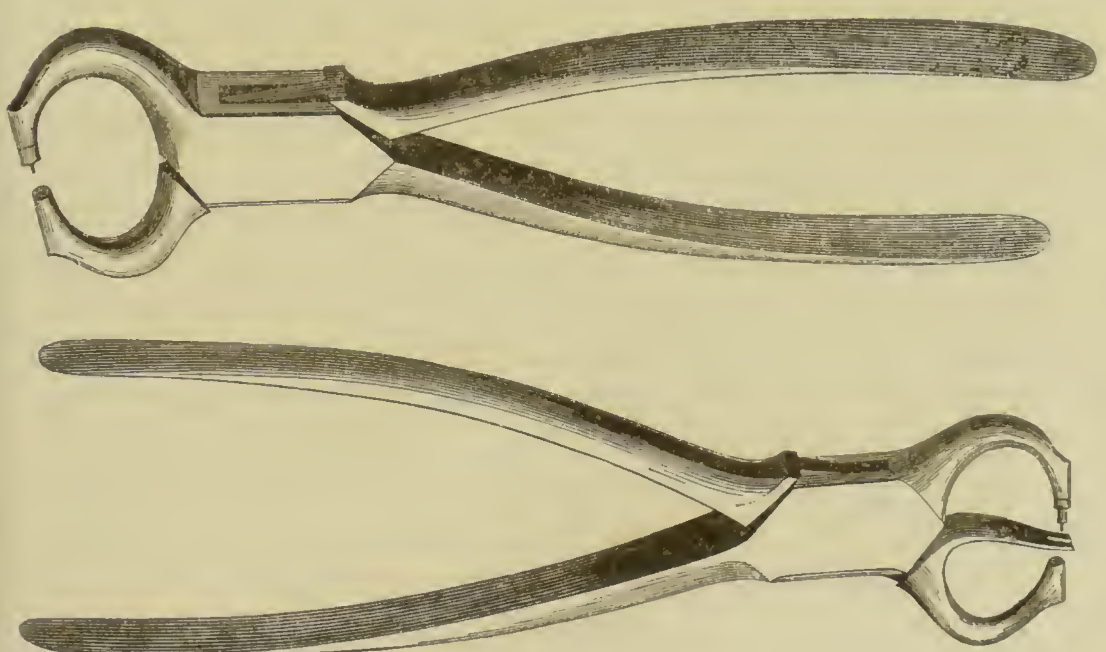
(Fig. 65.) The points upon the stay to be pierced for the admission of the platinum pins, may be ascertained by coat-

FIG. 65.



ing the surface of the former with wax softened in the flame of a spirit lamp, and pressing it first against the lower pin, the point of which will be indicated by an indentation of the wax. The backing is then perforated at this point with a plate punch, two forms of which are exhibited in Fig. 66,

FIG. 66.

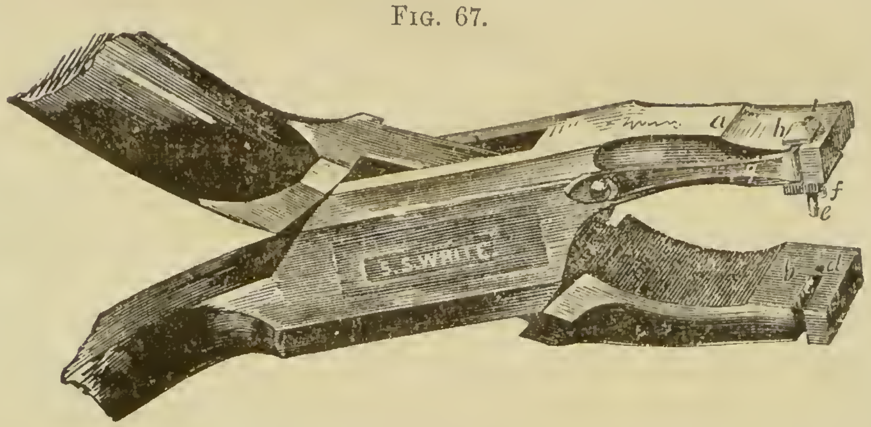


one armed with a tongue, which, when the plate is pierced, forces the latter from the punch. The strip is then reapplied

to the upper pin and the second hole obtained in like manner as the first. Instead of using wax, the ends of the rivets may be stained with some pigment, which will show the points to be pierced in the lining.

Fig. 67 represents an ingeniously contrived instrument,

FIG. 67.



invented by Dr. Samuel Mallet, and designed to secure an accurate relation of the two holes. After straightening the pins, one is placed in the hole *i*, at the head of the punch, the other pin pressing out the movable punch *c*, (which works by the spring *g*,) until it slips into the slot *h*; the two punches *f*, *e*, then make the holes at the exact distances apart to receive the pins.

The stay should be adapted accurately to the face of the tooth; it is then cut to the proper length, reaching nearly or quite to the point of the tooth, and then shaped with a file to the general form of the crown. When the stays are to be united they should be formed with a shoulder at a point corresponding with the neck of the tooth, and the proximate edges below united closely by square edges, or the latter may be beveled and made to lap upon each other. The process of soldering will be greatly facilitated and the piece will be more easily and artistically finished, by securing, in the first instance, a perfect coaptation of all the parts which are ultimately to be united. The sides of the holes in the stays facing the plate should now be enlarged or counter-sunk with

a spear-shaped or conical bur drill, and when applied to the teeth, the projecting ends of the platinum pins are cut off even with the backings and then split and spread apart with a small chisel-shaped instrument; a head will thus be formed to the rivets when solder is fused upon them, and which will prevent them from drawing from the linings. All the lines of union between the several pieces should next be well scraped, exposing a clean, bright metallic surface to the solder; the seams are then smeared with borax, ground or rubbed in clean, soft water to about the consistence of cream;* after which small pieces of solder are placed along the joints and over the points of the platinum pins. The piece thus prepared is now placed in the furnace or ordinary fireplace in order to heat the entire mass throughout preparatory to soldering. The fuel most proper for this purpose is charcoal, either alone or combined with coke; the latter being preferable for the reason that charcoal alone is more quickly consumed, and burning away more rapidly underneath, the piece is liable to drop to the bottom of the furnace. The fuel should be broken into small pieces and built up around the borders of the investient in order that all parts of the latter may be uniformly heated. The heating process should be conducted gradually, for if the piece to be soldered is subjected suddenly to a high heat, the plaster will be displaced by the too rapid evolution of vapor, and the integrity of the porcelain teeth will be endangered. The piece may be allowed to remain in the fire until the plate acquires a visible red heat, when it should be removed, placed on a suitable holder, and the solder fused with the blowpipe. A broad, spreading flame should first be thrown over the entire surface of the plate and border of the plaster until the temperature of the entire mass is nearly that required to fuse the solder, and which is indicated by the

* Slate is often used for this purpose, but is unfit, as in rubbing the borax, loosened particles of the former become mixed with the latter and impede the flow of the solder, and becoming entangled render it unclean and porous. Ground glass or a porcelain slab is the best for the purpose.

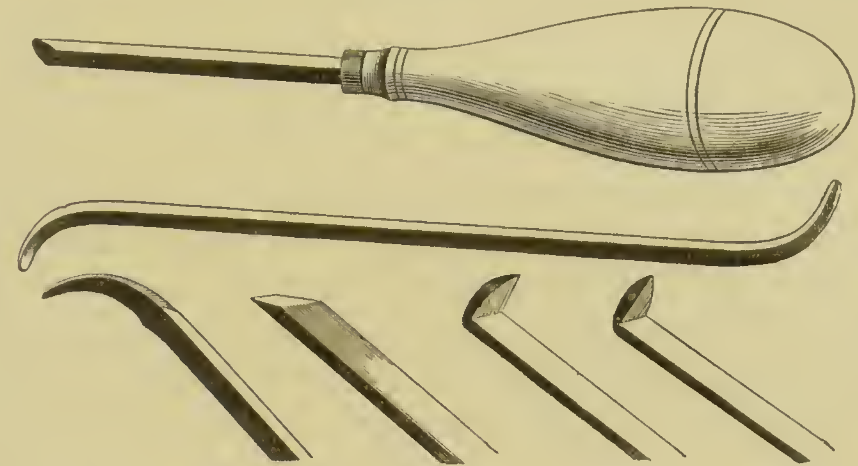
latter settling and contracting upon itself; the flame may then be concentrated upon a particular point, as at the heel of the plate on one side, passing round from tooth to tooth, until all parts are completely united and the solder is well and uniformly diffused.

Having united the teeth to the plate, the piece may be allowed to cool gradually, or it may be plunged after the lapse of a few minutes into boiling water without risk of injury to the teeth. When cool, the plaster is removed and the plate placed in a solution of equal parts of sulphuric acid and water, where it may be allowed to remain until the discoloration of the plate and the remains of the vitrified borax, incident to soldering, are removed; or it may be put into a small copper vessel, partly filled with the same solution and boiled for a few minutes. After removing the plate from the acid, it should be boiled for five or ten minutes in a solution of chloride of soda or common salt and water to remove thoroughly all traces of the former. Superfluous portions of solder are now to be removed, and this at first may be more quickly accomplished by the use of burs of various forms and sizes attached to a lathe. After the rougher and more redundant parts are thus cut away, any remaining irregularities upon the surface may be further reduced with properly formed files, scrapers and cutting instruments. Flat and half-round curved files, and scrapers having a right and left curvature to their cutting edges, and chisel-shaped cutting instruments for paring or chipping away, (Fig. 68,) are the implements usually employed for this purpose, and with which a comparatively smooth surface may be obtained; after which, the filed portions should be well rubbed with scotch stone until all traces of file-marks or other scratches are completely removed. With a rapidly revolving brush attached to a foot-lathe, the final polish or lustre may be imparted by the use first, of Spanish whiting, or prepared chalk, and then rouge mixed with water or alcohol.

The following method of finishing plate-work, communi-

cated by Prof. J. L. Suesserott,* embodies some practical suggestions in reference to this process: "The first step is to

FIG. 68.



procure, and attach to the lathe, a three or four-pronged fork, or a screw such as is used for withdrawing a load from a gun; upon this a good smooth cork is fixed, and with a sharp knife, turned to any desired shape. The cork is saturated with water as well as it can be, and powdered pumice placed upon it. If we have been careful to remove all excess of solder from our work, which can easily be done by a bur attached to the lathe,—we can, with the cork and pumice, make a very smooth surface, and this can be still more perfectly accomplished by substituting a very finely powdered spar for the pumice, after we have removed the largest scratches with the latter. By continuing the cork for a little while after the above named powders have been used off, we avoid the use of the scotch stone; and finally we dispense with the burnisher, by taking a new cork with a piece of chamois or buck skin stretched upon it, and going over the plate in the same manner as before, with the lathe revolving very rapidly.

"A higher color can be given to the plate by the use of the burnisher after the above proceeding, but we can certainly not produce a smoother surface.

* Erroneously ascribed in the former edition to Prof T. L. Buckingham.

"Some precaution is necessary by those who have never used the lathe in finishing the plate: in the first place the careless use of the bur, in removing the excess of solder, might result in the weakening of the piece by removing more than necessary, or, what would be still worse, holes might be cut entirely through the plate. Again, in polishing, if a little care is not taken, the fork or screw, whichever is used, may pass through the cork, and before the operator is aware, he will have inflicted an injury that will be difficult to repair. A small amount of experience—that which is essential in the proper performance of every nice operation—will enable almost any one, even those, to use a common expression, 'whose fingers are all thumbs,' to finish their work in about one-eighth of the time that the most expert workman would require for the accomplishment of the same by the old method."*

In the final adjustment of the finished piece to the mouth, and after any additional change in the form of the teeth necessary to secure the most perfect antagonism has been made, the patient should, in all cases of partial dentures, receive explicit directions in regard to the general care and management of the appliance and the remaining natural teeth. Ordinarily, there will be but little difficulty experienced by the patient in the immediate and successful use of a substitute supported in the mouth by clasps, or any equivalent means, but in the case of atmospheric pressure plates, the patient should be candidly advised of the probable want of stability incident to the first use of the appliance, and the consequent annoyance which, in many cases, follows its occasional displacement in mastication until such time as the adaptation of the several parts to each other are perfected, and the patient has acquired a habit of controlling and directing the forces applied to the substitute. The time necessary to accomplish these results will depend much upon the form and condition of the mouth, a favorable or unfavorable

* Dental Cosmos, vol. i. p. 330.

antagonism, the adaptation of the plate, and the aptitude and temper of the patient. It will be prudent and but just to the patient, to state, that the complete utility of an appliance sustained by atmospheric pressure, will not, probably, be realized in less time than from four to six weeks ; and this estimate of time, in a majority of cases, will be fully justified by experience in the cases under consideration.

The importance of thorough and absolute cleanliness of the substitute and natural teeth, and the reasons therefor, should be clearly stated ; and the comfort, utility, and durability of the artificial fixture, as well as the safety of all the remaining natural organs will depend, in a great measure, upon the fidelity of the patient with respect to the observance of these injunctions. In those cases especially, where clasps are used, the substitute should invariably be removed after each meal and cleansed, while the teeth clasped, should, at the same time, be freed from deposits of food or other foreign substances with a brush, or any of the means usually recommended for the purpose.

CHAPTER XI.

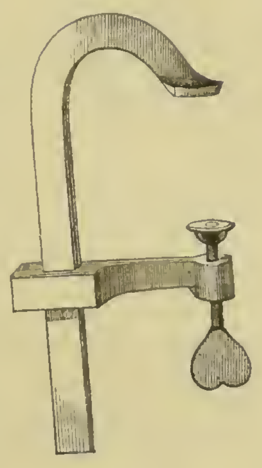
ENTIRE DENTURES.

Method of Constructing a Plate Base for an Entire Denture for the Upper Jaw.—The general form and dimensions of the required base to be used as a support for a complete denture for the upper jaw may first be indicated by drawn lines upon the plaster model, and a sheet-lead pattern obtained from this to serve as a guide in securing the form of the plate to be swaged. Whenever the substitute for the upper jaw is designed to be retained *in situ* by the external pressure of the atmosphere, and especially where a central air chamber is employed, the plate should be made sufficiently ample in its dimensions to cover all the hard palate, the alveolar ridge, and all portions of the external borders of the latter not directly encroached upon by the muscles and reflected portions of the mucous membrane of the lips and cheeks.

Before swaging, the plate should be well annealed, and its central portion brought as nearly as possible to the form of the palatal face of the die with the mallet, forcing the heel of the plate down in advance of the portion covering the more anterior concavity of the arch, preventing thereby a doubling of the posterior edge of the plate upon itself. This central portion may also be forced more perfectly into adaptation with a partial counter before swaging in the ordinary manner, and this is advisable in all cases when the palatal arch is very deep; but as this is very liable to be drawn from the arch in the process of turning the borders of the plate over upon the ridge, a useful contrivance has been invented by Dr. Rurras,

of New York, to prevent the displacement. Fig. 69 shows the form of this instrument. The die and plate are placed near the edge of the bench, and the upper part of the clamp adjusted over the central portion of the plate; the two pieces are then bound firmly to the bench by tightening the screw underneath. A protective piece of buckskin, cloth, or paper, should be placed between the plate and clamp to prevent former from being bruised or indented. The margins of the plate are now turned over upon the ridge, and if the external borders of the latter are undercut or stand even vertically, the edges of the former will tend to double upon themselves at such points, and hence it will be necessary, before swaging, to split the plate in front, and, in some cases, one each side, and wherever divided, a V-shaped piece may be cut out of sufficient width to allow the divided edges to overlap slightly when approximated in the process of swaging. The proximate edges of the divided sections should be filed to a thin edge before swaging, so that when brought together and soldered, there will be but little additional thickness of the plate at such points. The cut portions should not be soldered until after a partial or complete swaging.

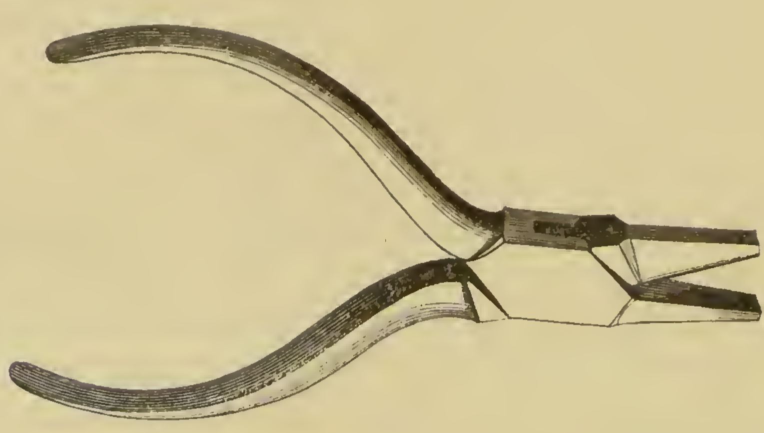
Fig. 69.



Having conformed the plate as nearly as practicable to the die with the mallet and pliers (Fig. 70,) or with plate forceps constructed for the purpose, (Fig. 71,) it should be placed between the die and counter, and the latter forced together with a heavy hammer until a tolerably accurate coaptation of the plate is obtained, the latter being frequently annealed during the process of stamping, to render it more pliable. At first, considerable yielding and consequent deformity of the counter-die will occur; hence, after partial swaging, another should be substituted and the process continued

until the greatest possible accuracy of adaptation is secured. If the face of the die is marked by prominent and sharply

FIG. 70.



defined ruga, or other irregularities, such points will, to some extent, be bruised or flattened; it will therefore be expedient in such cases, and better perhaps in all, to finish the

FIG. 71.

swaging with a new and unused die and counter, in which case two or three moderate, steady, and well-directed blows of the hammer will be sufficient.

If the plate is brought into uniform contact with all parts of the face of the die, this conformity is the only reliable test of its adaptation out of the mouth. In no case will the swaged plate fit the plaster model perfectly, inasmuch as the unavoidable contraction of the die, however slight, will, especially in deep-arched mouths, cause the plate to bind on

the posterior and external borders of the ridge, preventing it from touching the floor of the palate; while the bruising, though inconsiderable, of the more prominent points upon the die, and a corresponding flattening of the plate at such points, will prevent uniform contact of the latter with the unchanged surface of the plaster model.

After final swaging, the plate should be again annealed with a heat nearly or quite equal to that which will be ultimately required in soldering; after this any additional swaging should be avoided, unless the plate warps in the heat and which may be determined by applying it to the die; if any change has occurred, it should be re-swaged and again annealed at a high heat, and the operation should be repeated, if necessary, until the plate retains its integrity of form after the last annealing. This process of final heating does not apply to silver if in the form of a swaged plate, as this metal invariably suffers some change of form when subjected to an annealing heat.

Modifications in the Form of Plates for Entire Upper Dentures.—Whenever a central air chamber is employed, it may be constructed in either of the ways described when treating of partial atmospheric pressure plates. The general form of a plate for an entire upper denture, with a central chamber, is exhibited in Fig. 72, other modifications in

FIG. 72.

FIG. 73.

the form of cavity plates for full upper sets are in limited use, as where chambers are arranged one on each side of the sloping walls of the palate, or directly over that portion of

the ridge previously occupied by the anterior molar and the bicuspids on each side, as seen in Fig. 73, called "Lateral Cavity Plates." Dr. M. Levett, of New York, has recently introduced another modification of cavity plate, consisting of a number of small air chambers arranged directly over the ridge and placed at short intervals throughout the entire border. It is claimed that plates constructed in either of the ways last mentioned cohere with equal firmness to the jaw and are less liable to "rock" in the mouth than when formed with a central chamber. Whatever their general utility may be, cases doubtless occur where they may be advantageously employed, as when any great inequality exists in the hardness of the ridge and palate, and a plate constructed in the ordinary manner is dislodged by "riding" upon the hard palate when forces are applied to the ridge on either side.

It has been recommended, after having constructed a base of the form represented in Fig. 72, to cut through the plate immediately in front of the central chamber, making an opening of a semi-lunar form. It is claimed that, by the more ready application of the tongue to this part, the air contained in the chamber, when the plate is applied to the mouth, may be more easily and thoroughly exhausted. There is great danger, however, of the soft tissues being drawn into the opening, in which case it can scarcely fail to produce injury of the parts implicated; the expedient, therefore, is seldom resorted to.

There is still another form of cavity plate known as Cleveland's modification of air-chamber, and which is constructed in the following manner: A plate like that exhibited in Fig. 72 is first struck up and the chamber cut out. A thin sheet of wax, or a layer of plaster, is then placed upon the lingual side of the plate, extending from two to three or four lines from the edges of the orifice in the main plate; a thin, retreating edge is given to the wax or plaster at the outer borders, making it continuous with the surface of the plate.

The plate with the wax attached may now either be tacked to the model with softened wax along its outer borders, and shaped in such a way as to permit the model and plate to be withdrawn from the sand, and a mold of the parts taken in the ordinary way, and from this a die and counter; or an impression in wax or plaster may be taken of the lingual face of the plate and wax, and afterward a model, die, and counter. With the latter, a second plate, covering nearly or quite all of the palatal concavity is swaged, and when this is applied to the main plate over the cut chamber, and united by soldering, a space, equal to the thickness of the wax or plaster placed on the primary plate, will be found to exist between the two lamina. Fig. 74 exhibits a transverse section of the two plates, disclosing the space between them, and also the opening through the gum plate into the cavity. Before soldering on the duplicate plate, a half-round wire should be soldered around the opening in the palatal plate on its lingual side, to protect the soft tissues of the mouth from injury when drawn in as the air is exhausted from the chamber; or, what is preferable, this form of cavity may be converted, practically, into what is known as "Gilbert's chamber," (which is the central swaged chamber before described,) by filling in the space between the two plates with some impervious substance, as Hill's filling, or an amalgam of gold, the excess of mercury being driven off by heat. In the construction of continuous gum work, the interspace may be filled in with gum body. The advantages of these double plates are, a greatly increased strength imparted to the base, a diminished liability of warping in the process of soldering, a smoother surface presented to the tongue, and a more decidedly angular form of the chamber.

Fig. 74.

In whatever way the plate is formed, a notch or fissure of sufficient depth to receive and permit an unobstructed play of the frænum of the lip should be formed in the front part of the plate, while the borders of the latter nearly opposite the anterior molars on each side should be narrowed to prevent undue contact of its edges with the folds of the mucous membrane stretching obliquely across from the cheeks to the jaw. Care should also be taken to trim away from the heel of the plate any portions that might otherwise encroach upon the soft palate.

It is only in the fewest number of cases that a rim can be swaged to form a groove or socket properly situated for the reception of the plate extremities of either single gum or block teeth, as it will usually be found impracticable to adjust the gum extremities to the socket thus formed without necessitating, in some degree, a departure from a just arrangement and antagonism of the teeth. Whenever it is thought best, therefore, to rim the plate, it will generally be necessary to adjust and solder a separate strip to the plate along the plate ends of the teeth after the arrangement of the latter on the base is completed.

After the plate has been worked as nearly as possible into the required form, it should be applied to the mouth of the patient to ascertain the correctness of its adaptation to the parts before proceeding further with the operation. If the adaptation is found imperfect, the fault lies either in the impression, or in undue contraction of the die. In the former case, another impression should be taken, and the plate reswaged; in the latter, a less contractile metal or compound should be employed in the formation of the die. To determine the practical efficiency of the adaptation and adherence of an atmospheric pressure plate, various tests may be applied. The coaptation of its borders to the external walls of the ridge may be ascertained by inspection, and the patient's sense of contact or non-contact of its central portion with the floor of the palate may, in some degree, be relied on as evidence of

the accuracy of its adjustment to parts not visible. The tenacity with which the plate adheres on the application of direct traction, cannot always be relied upon, inasmuch as a well fitting plate will sometimes be readily dislodged in this manner, while, on the contrary, one but illy adapted to the parts may require considerable force to separate it from the jaw when acted on in the same way. The most trustworthy test of actual or practical stability is firm pressure applied alternately over the ridge on each side and in front. If the plate maintains its position and remains fixed under repeated trials of pressure applied in the manner indicated, the adaptation may be safely relied on; if it slides upon the palate or is easily disengaged from the mouth, the instability of the plate may be referred in many cases, not to a want of coaptation, but to a want of uniformity in the condition of the parts on which the plate rests. Thus, for example, if the ridge along the mesial line of the palatal vault is more than usually prominent and incompressible, and the alveolar ridge relatively soft and yielding, the plate, meeting with a fixed point of resistance at the floor of the palate, will prevent the ridge from being sufficiently compressed when the atmosphere is exhausted from underneath the plate; and hence, when forcible pressure is made on one side over the ridge, the plate, riding upon the resistant surface in the arch, will be thrown off from the opposite side. Whenever, therefore, the conditions alluded to prevail to any considerable extent, a perfect coaptation of the plate to the parts, instead of favoring the retention of the former, will impair its stability for all practical purposes. The remedy is found in so constructing the plate that, when adjusted to the mouth, and before the air is exhausted, a greater or less space will exist between the central portion of the plate and palate, but which, when a vacuum is formed, will be carried up into contact with the roof of the mouth, and at the same time compress the ridge sufficiently to afford a firm and resisting basis for the plate in mastication. This peculiar adaptation of the plate may be obtained by

adjusting a piece of sheet-lead or wax plate over the central ridge on the plaster model, by means of which the corresponding portion of the plate, when swaged with a die obtained from the model so prepared, will be thrown far enough from the roof of the mouth to answer the purpose before indicated. This will be more particularly necessary in shallow arches; while, if the arch is very deep, or even moderately so, the unavoidable contraction of the die may render the expedient unnecessary.

Method of Constructing a Plate Base for an Entire Denture for the Under Jaw.—Aside from the differences in the form of the plate, and the manipulations incident thereto, the process of constructing a plate for the under jaw does not differ essentially from that already described in connection with full upper dentures.

If the lower plate is constructed from a single lamina of gold, or other metal, it should be somewhat thicker than that used in upper cases, and should also be of finer quality, as the additional thickness of the plate and the peculiar form of the inferior maxilla, renders a greater degree of pliancy necessary in swaging it to the form of the ridge. The general form of a base for an entire lower denture is exhibited in Fig. 75. The internal border of the plate should usually be doubled,—either by turning the edge over in swaging. or by soldering on a narrow strip of plate or half-round wire.

Fig. 75.

A more perfect adaptation of the plate to the ridge may be obtained by the use of a double instead of a single plate, in which case a thin basement plate, not exceeding No. 30 of the gauge, should be swaged to the form of the ridge in the first instance, and then a duplicate plate, swaging the two together and uniting them to each other with solder. A plate of the specified thickness may be very readily and accurately conformed to any irregularities in the ridge, and

when the two are united, the base will be heavier and stronger than a single lamina of the ordinary thickness. Instead, however, of doubling the entire plate, it will be sufficient, in most cases, to adapt the second plate only to the lingual surface of the first, extending it up from the lower edge to a point corresponding as nearly as possible with the posterior portions of the base of the teeth when the latter are adjusted to the plate, (Fig. 76.) A moderately thin plate may, in this manner, be used for the primary base, while the duplicate band will impart the requisite strength to the plate, and, at the same time, obviate the necessity of wiring its inner edges. In adopting either of the last named methods, the plates, after they are united to each other, should be again swaged to correct any change of form incident to the use of solder.

Fig. 76.

Antagonizing Model for an Entire Upper and Lower Denture.—Either of the following methods may be adopted in securing an antagonizing model for complete dentures:

1. Attach to the ridge of each plate a roll or strip of adhesive wax corresponding in width to the length of the teeth which will be required for each plate respectively; place the plates, with the wax attached, in the mouth, and trim away from the proximate edges of the wax until the two sections close upon each other uniformly throughout the circle; then cut away from the labial surfaces of the rims of wax, above and below, until the proper fullness and required contour of the parts associated with the lips and mouth are secured. The approximation of the two jaws, when the finished substitutes are ultimately adjusted to the mouth, will depend altogether upon the aggregate width given to the two sections of wax at this stage of the operation, and it is, therefore,

important that the "bite" or closure of the jaws secured at this time should be such as will most perfectly fulfill the requirements of the case in respect to the utility and comfort of the appliance, and the proper restoration of the required facial proportions. If there is any considerable change produced in the relation of the jaws habitual to them prior to the loss of the natural teeth, the characteristic expression of the individual will, in some degree, be changed or marred; an unaccustomed and restrained action will be imposed upon the muscles concerned in the movements of the lower jaw, which will render the use of the appliances at least temporarily, if not permanently, uncomfortable and fatiguing, or even painful; while the utility of the fixtures may be impaired or wholly destroyed, by compelling a particular application of forces in mastication inconsistent with their stability in the mouth. No specific directions, of course, can be given that will apply to all cases, but it may be observed that, ordinarily, the two sections of wax should be cut away from their approximating surfaces until the jaws close sufficiently to permit the edges of the lips to rest easily and naturally upon each other when in a relaxed condition, or the upper rim may extend somewhat below the margin of the upper lip, while the lower section of the wax is cut away on a level with the lower lip, or a little below it. Cases occur, however, where a less exposure of the upper portion of wax, even though quite narrow, will be required; as where the alveolar ridge is very deep, and the lip covering it either absolutely or relatively short, or where the latter is retracted, exposing, even when in a state of repose, a greater portion or all of the crowns of the teeth, and in extreme cases, the margins of the gum. Between the latter extreme, and an inordinate extension of the upper lip below the ridge, all intermediate conditions occur, and the practitioner, aiming to produce an agreeable, harmonious and truthful expression of all the parts, must rely wholly upon his judgment in reference to the necessary approximation of the jaws, the

restoration of the natural fullness and contour of the mouth, and the relative length to be given to the upper and lower teeth.

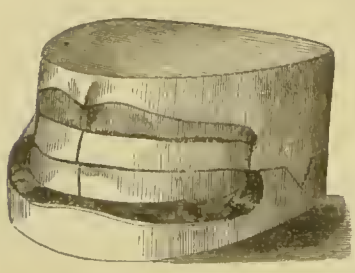
Patients, when requested to close the mouth *naturally*, are very liable to *project* the under jaw; hence it is well to have them open and close the jaws frequently, observing, at the same time if the separate portions of wax meet in precisely the same manner at each occlusion. If the bite varies at every approximation of the jaws, the patient should be directed to relax and abandon for the moment all control over the muscles of the lower jaw; the operator should then grasp the chin and press the jaw first directly backward and then upward until the opposing surfaces of the wax meet; in which position it should be steadily held by the patient until the two portions of wax are attached to each other in that particular relation. The latter may be done by drawing lines vertically across the rims of wax at various points which will serve to indicate their relation to each other when out of the mouth; or a heated knife-blade may be passed between the two sections, the melted wax temporarily uniting them. A very convenient and secure method is to attach them together by means of two strips of metal bent in the form of a staple; these may be warmed in a spirit-flame, and pressed into the wax, one on each side—one end penetrating the upper rim of wax, the other the lower. Before removing the plates, the mesial line of the mouth should be indicated upon the wax by drawing a line vertically across the latter in front to serve as a guide in the arrangement of the central incisors.

2. Another method is to attach to either the upper or lower plate a single rim of wax somewhat wider than will be required for both the upper and lower teeth. The plates are then placed in the mouth, and the jaws brought together, imbedding the opposite plate in the wax. When this method is adopted, the proper closure of the jaws is best determined by a gauge or guide consisting of a strip of plate or other substance encased in the wax and interposed edgewise between

the borders of the two plates in front, in such a manner that when the latter are approximated they will close upon the guide, the desired relation of the jaws to each other having been previously ascertained by trial of the guide with the plates in the mouth before adjusting the wax. The exterior surface of the wax rim is then trimmed away, or additional portions added to it, until the proper fullness and contour are given to the lips; after which the median line of the mouth should be traced upon the wax in front, as before described.

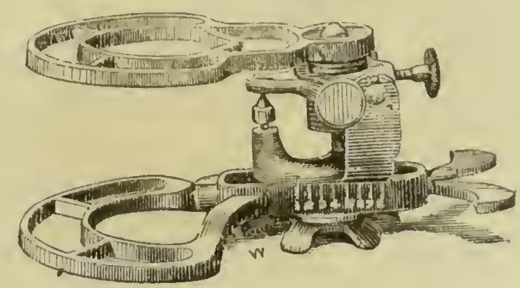
The plates, attached to each other in either of the ways mentioned, having been removed from the mouth, a batter of plaster may be poured upon a piece of paper or other substance, forming a layer a fourth or a half an inch thick and two or three inches long, when the under surface of the lower plate may be imbedded in one end of the plaster, and the remaining portion of the latter projecting from the heel of the plate trimmed and formed for articulating with the second piece of the antagonizing model in the same manner as described when considering partial dentures. The entrance to the cavity between the two plates is now closed up with a sheet of softened wax or otherwise, and the whole surrounded by a piece of oil-cloth, wax, or other substance, and the second part of the model obtained by pouring plaster in upon the exposed surface of the upper plate and the plaster posteriorly to the depth of half an inch or more. When the plaster is sufficiently condensed, the line across the wax in front should be extended in a direct line across the borders of the plaster model above and below, as, in arranging the teeth, the wax will be cut away, and without this precaution the mesial point of the mouth may be lost. The form of an antagonizing model for an entire upper and lower denture, with the plates and wax attached, the latter being cut away somewhat preparatory to adjusting the teeth, is shown in Fig. 77.

Fig. 77.



Various articulators, or antagonizing frames have been devised, and may be substituted for the plaster articulator just described. A very excellent adjustable contrivance of the kind, invented by Dr. Hayes, is exhibited in Fig. 78. With this appliance, all the motions of the jaws can be represented, and the relative positions again brought back at pleasure to the starting point. The screw hinge admits lateral motion. The set screw on the side plays into a slot, securing one central position, to which it can at all times, when desired, be brought back. The long screw in the foot produces back and forward motion, the main hinge, up and down motion; and the large nut on the bottom renders all the parts taut and unyielding.

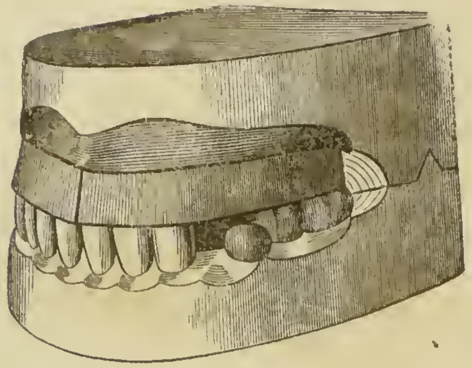
FIG. 78.



Antagonizing Model for an Entire Upper Denture with the Natural Teeth of the Lower Jaw remaining.—In forming an antagonizing model to be used as a guide in arranging and articulating a full upper denture where all or a part of the natural organs of the inferior jaw are remaining, a rim of wax should first be adjusted to the borders of the plate, one or two lines wider than the required length of the artificial teeth. When placed in the mouth, the exterior surface of the wax draft should be cut away or added to, until the proper fullness of the parts is restored. The patient should then close the lower teeth against the wax, imbedding them just sufficiently to indicate the cutting edges and grinding surfaces of the opposing teeth. If a fuller impression of the exterior faces of the lower teeth are required, it may be obtained by pressing in a small strip of softened wax against them and the lower edge of the rim of wax upon the plate; or the projecting borders of the latter may be forced down upon the crowns with the fingers. The median line of the

mouth is then indicated upon the wax, the plate removed, and its palatal surface imbedded in one end of a layer of plaster spread upon a strip of paper; the portion of plaster extending from the heel of the plate trimmed, grooved, varnished and oiled; the entire piece enclosed, and plaster poured in upon the exposed surfaces of the wax and plaster to the depth of one-fourth or one half of an inch. The two sections of the model, with the plate and wax attached, the latter being cut away somewhat to receive the porcelain teeth, is exhibited in Fig. 79.

Fig. 79.



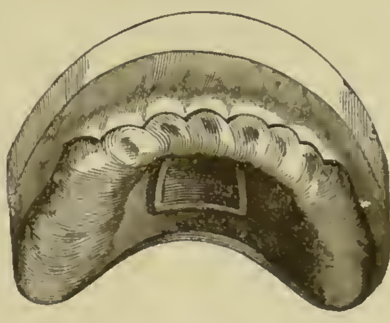
Selecting, Arranging, and Antagonizing the Teeth; Rimming the Plate; Attaching Spiral Springs; Investing, Lining, Soldering, and Finishing.—In *selecting* teeth for an entire upper and lower denture, the special requirements in respect to size, form, and color, will depend, in a great measure, upon the complexion, age, sex, general configuration of the face, &c., of the patient. Every separate denture, therefore, that is constructed in strict conformity with a faithful interpretation of the special requirements of each individual case, will be characterized by shades of differences in the color, form, size, and arrangement of the teeth of replacement. It will be sufficient in this connection to observe that such selection of the teeth should be made as will most perfectly reproduce the lost proportions of the facial contour, and impart to the individual a natural, harmonious, and agreeable expression.

In *arranging* or adjusting single gum teeth to the plate in those cases where the changes in the form of the alveolar ridge, consequent on absorption, are completed, the portions applied to the base should be ground away sufficiently to restore the required fullness of the parts and to give proper

length and inclination to the teeth. The coaptation of the ground surfaces to the base should be accurate enough to exclude perfectly particles of food, and to furnish such a basis to each tooth as will provide most effectually against fracture when acted upon by the forces applied to them in the mouth. The gum extremities of the teeth should also be accurately united to each other laterally by grinding carefully from their proximate edges until the joints or seams will be rendered incapable of ready detection in the mouth,—care being taken that this coaptation of the adjoining surfaces is uniform, for if confined to the outer edge alone, portions of the gum enamel may be broken away in the process of soldering.

In the construction of substitutes designed to fulfill only a temporary purpose, and where the alveolar processes remain in a great measure unabsorbed, and plain teeth (those representing but the crowns of the natural organs) are used, but little skill will ordinarily be required in adjusting and fitting them to the base. If the ridge in front is prominent and but inadequately concealed by the lip, as where the teeth have been but recently extracted, all those portions of the border of the plate in front anterior to the first or second bicuspid on each side may be cut away on a line a little within the required circle of the anterior teeth, and scolloped, (Fig. 80,) permitting the anterior cervical portions of the artificial incisors and canines, and, in some cases, the anterior bicuspids, to overlap the edge of the plate and rest directly upon the gum in front. This abridgment of the plate will not ordinarily materially affect the adhesion or stability of the substitute.

FIG. 80.

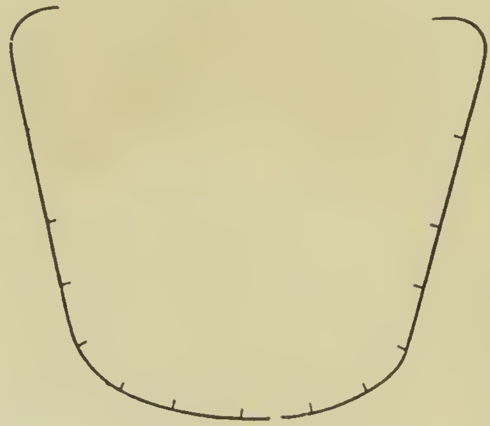


There are cases of a mixed character that render it more difficult to effect a harmonious and symmetrical arrangement of the teeth, as where a limited number of the natural teeth at intervals have been long absent and the excavations in the

ridge consequent on absorption alternate with other points upon the ridge in a comparatively unchanged condition. To give uniformity to the denture by restoring perfectly the required circle of the arch in such cases will necessitate the employment of plain and single gum teeth conjointly. Whenever necessary, those portions of the base occupied by the plate teeth may be cut away in such a manner as to permit the latter to be adjusted directly to the unabsorbed gum as before described.

In the process of grinding the teeth to the base, above and below, the operator should commence by first arranging the superior central incisors and then the lower, and so passing back from tooth to tooth, grind and adjust an upper and lower tooth alternately, keeping the upper ones in advance of those of the lower jaw. The central incisors above, should be placed parallel with each other, but the cutting edges of the laterals, and the points of the canines, should incline slightly toward the median line of the mouth. In arranging the teeth of the upper jaw, the anterior six may be made to describe, with more or less exactness, the segment of a circle, but a somewhat abrupt angle may be given to the arch on each side by placing the first bicuspids within the circle in such a way that, when standing directly in front of the patient and looking into the mouth, only a narrow line of the exterior face of the crowns of these teeth will be seen, while the remaining teeth posterior to them, should be arranged nearly on a straight line, diverging as they pass backward. When arranged in the manner described, the peripheral outline of the arch will exhibit somewhat the form presented in the above diagram, (Fig. 81.)

Fig. 81.



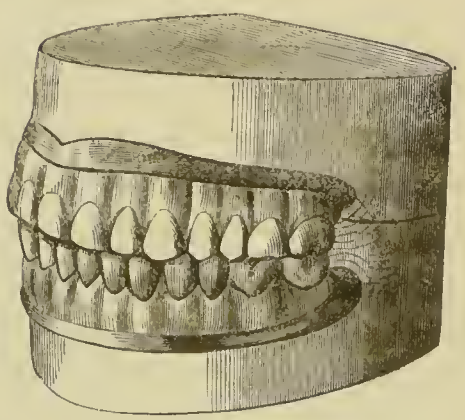
In regard to the practical efficiency of an upper denture

retained in the mouth by atmospheric pressure, it is important that the teeth engaged in the comminution of food, as the bicuspids and molars, should occupy a position directly over the central line of the ridge, and should either be arranged vertically or with a slight inclination toward the centre of the mouth. The liability to displacement of the substitute in mastication will thus be greatly diminished, whereas, if placed outside of the line indicated, and especially with a diverging inclination, the stability of the appliance will be endangered, and the function of mastication impeded, notwithstanding other conditions necessary to complete success have been fully secured. In arranging the upper and posterior teeth as described, it will sometimes be necessary to give to the opposing under teeth a decided inward inclination in order to effect a satisfactory antagonism of the teeth; and cases occur where a practical articulation cannot be secured without departing in some degree, from the arrangement of the upper teeth spoken of,—as where a great disparity exists between the posterior transverse diameters of the two jaws, a medium sized, or even small, arch above being associated with an expanded ridge below.

In articulating the upper and lower teeth, the closure or relation of the natural organs should be imitated as nearly as the other essential requirements of the case will admit of. Hence the upper front teeth, describing the segment of a larger circle than the corresponding teeth of the lower jaw, will project beyond and overlap slightly the cutting edges of the latter; and having a greater width of crown, they will extend latterly beyond the opposing teeth, covering one-third of the crowns of those next adjoining, so that when the canines of the upper jaw are reached, they will close between the lower canines and first bicuspids; and, passing back, the anterior superior bicuspids between the first and second bicuspids below; the posterior bicuspids above between the second inferior bicuspids and anterior molars; the first superior molars between the first and second molars below;

while the anterior half of the posterior molars above will close upon the posterior half of the inferior second molars, the remaining posterior half of the second molars above extending posteriorly beyond those of the lower jaw. The outer cusps of the superior bicuspids and molars will overlap those of the inferior teeth; while the inner cusps of the teeth of the superior jaw will pass into the depressions in the lower teeth formed by the internal and external cusps, and the external cusps of the inferior teeth will, in like manner, be received into the corresponding excavations of the upper teeth. The relative position and antagonism of the teeth as they appear in a regularly arranged denture for both jaws, are shown in Fig. 82. An abnormal relation of the jaws, as where undue projection, absolutely or relatively, of either maxilla exists, or where the lower jaw closes on one side or other of the upper, will frequently compel a departure from the ordinary arrangement of the artificial organs, the extent of which must be determined by the necessities of each individual case.

Fig. 82.



In selecting teeth for a full upper denture in those cases where natural teeth are remaining below, or *vice versa*, the color, size, and form of the latter, will serve as a guide in the choice of teeth appropriate for the opposite jaw. In fitting and arranging the teeth upon the base, and in antagonizing them with the opposing natural teeth, the same general principles apply as those already adverted to in connection with full upper and lower dentures.

Having adjusted the teeth to the base, they should be placed in the mouth before uniting them permanently to the plate, to detect and remedy any error of arrangement either

in respect to prominence, position, inclination, length, or antagonism.

Forming a Rim to the Plate.—If the case is one where single gum or block teeth are employed, and it is intended to form a socket or groove upon the borders of the plate for the reception of the plate extremities of the teeth, the rim forming the groove should be fitted and soldered to the base before investing the piece in plaster. If the alveolar ridge above is shallow, and but imperfectly concealed by the lip, a rim to the plate will be inadmissible, as, when the mouth is opened and the lip retracted, as in laughing, the metallic band will be exposed to view. A rim may be fitted and attached to the base in either of the following ways:

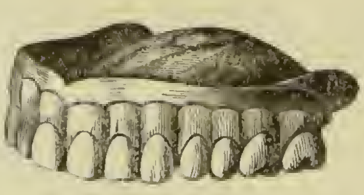
1. A strip of plate from one to two lines in width is adjusted to the plate with one edge resting on the uncovered border of the plate close to the gum extremities of the teeth, and the other overlapping and embracing the latter. The rim may consist of one entire strip extending from heel to heel of the plate, and passing round the posterior molars to unite with the stays; but it may be more conveniently adjusted by employing two pieces, extending from each heel of the plate, and uniting in front.

2. A half-round wire with the edge beveled where it joins the ends of the teeth, forming a narrow groove, may, in like manner, be fitted to the plate, furnishing a shallow bed for the gum extremities of the teeth. A narrow strip of plate, about the thickness of a heavy clasp material, may be substituted for the half-round wire. In either case, the better plan is first to trace the outlines of the gum portions of the teeth upon the plate with a sharp instrument; remove the wax and teeth from the plate; draw another line a little within the first all round, and solder the rim to the line last drawn; remove the teeth from the wax, and re-adjust the latter in its proper place upon the plate; then fit each tooth separately to the rim by grinding away sufficiently from the end of the tooth to effect an accurate adjustment of it to the

socket. The ends of the teeth may be ground away to the rim until the platinum pins freely re-enter the rivet holes in the wax, thus restoring them to their proper position in relation to the base.

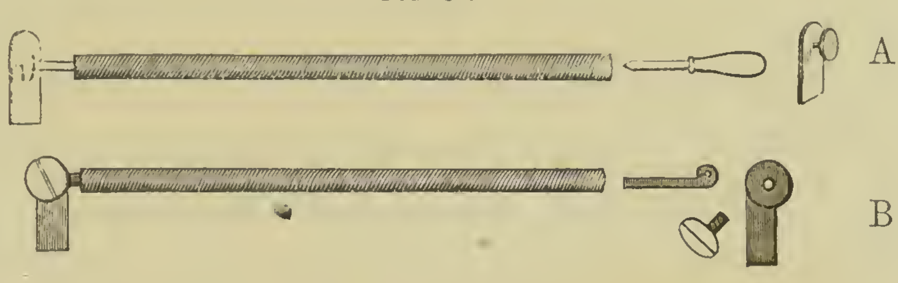
3. Another method of forming a rim consists in swaging a strip of plate accurately to the form of the parts to which it is applied. An impression in wax or plaster is first taken of the gum surfaces of the teeth and exposed border of the plate; but as it will be impossible to detach either wax or plaster in perfect condition, when encircling the entire arch, or to swage perfectly with a die so unfavorably formed for stamping, separate impressions of the two lateral halves of the piece should be taken,—from these plaster models; and from the latter, dies and counters;—with these, two strips of plate of sufficient width are swaged, each extending from the heel of the plate to a little beyond the median line in front, overlapping slightly at the latter point. The portions of the swaged strips embracing the plate ends of the teeth are then trimmed to the proper width, and scalloped, if desired, in correspondence with the festoons of the artificial gums. An upper denture rimmed in the manner last described is exhibited in Fig. 83. In whatever way the rim is formed, when it has been fitted to the plate and teeth, it may be held temporarily in place with clamps adjusted at two or three points around the plate, and then transferred to a piece of charcoal, and secured by first tacking it at two or three points with solder. The groove may then be filled with whiting, mixed with water or alcohol, to prevent the solder from flowing in and filling it up; after which small pieces of solder are placed along the line of union next the edge of the plate, and the rim permanently united throughout with the blowpipe; after which the wax and teeth are re-applied to the plate.

Fig. 83.



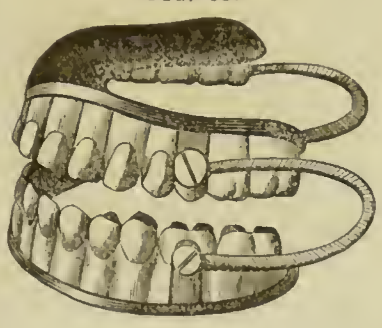
Constructing and Attaching Spiral Springs.—The success which has been attained in the use of atmospheric pressure plates has almost entirely superseded the necessity of employing spiral springs as a means of support; nor should the latter be resorted to except under circumstances that preclude the use of the former. When applied, they should be attached to the base on each side between the posterior bicuspid and first molar below, and opposite the posterior bicuspid above. To the border of the plate near the base of the teeth a narrow strip of plate is soldered, extending up and lying closely against the side of the latter—to the end of which near the grinding surfaces of the teeth is adjusted a small circular cap of gold connected with the standard by a small wire on which the looped extremity of the spring plays. To each end of the spring is attached a gold wire, doubled upon itself in such a way as to form a loop, the closed ends being soldered together and filed to enter the

FIG 84.



hollow in the wire, A, Fig. 84. B, Fig. 84, copied from Prof. Harris' work on Dental Surgery, represents another method of attaching springs, but the former is more readily constructed and will answer every practical purpose. Fig. 85, exhibits the application of springs to an upper and lower denture.

FIG. 85.



Investing, Lining, Soldering and Finishing the Plate.—The plate, with the wax and teeth in place, is next encased in a mixture

of plaster preparatory to lining the teeth and uniting them with solder to the base. For this purpose, plaster and sand may be employed, using as little of the former as will serve to hold the investment together during the subsequent manipulations. Asbestos may be added, and is a useful ingredient. Burnt plaster, or that which has been previously used for investing, may be substituted for the sand and asbestos, adding a sufficient quantity of unused plaster to effect consolidation. Either of the combinations mentioned will suffer but little change in the fire, if properly managed. It is customary to encase the piece in the plaster mixture to the depth of from one-half to three-fourths of an inch, leaving only the lingual surfaces of the plate and teeth uncovered. However comparatively free from change of form the best combinations of plaster may be, yet some slight contraction of the body of the investient doubtless ensues on the application of heat, and it is probable that so large and resistant a mass must tend, in some degree, to produce deformity of the plate in soldering; for, as the investient contracts and the plate at the same time expands when heated, a change in the form of the latter must occur whenever the force exerted by the shrinking plaster exceeds the expansive force of the metal; and when the peculiar form of the upper plate is considered we can readily conceive how a slight contraction of the plaster of the thickness mentioned may "warp" or "spring" the plate when its uniform linear expansion and contraction is so effectively opposed. The change in the form of the base from this cause will, according to the author's observations, be found, in an upper plate, to exist on each side of the sloping walls of the palate, embracing the posterior half or two-thirds of the plate at these points,—the change manifesting itself in an inward displacement of the lateral walls of the plate midway between the summit of the palatal arch and the most depending portion of the ridge. We would suggest in explanation of this result that, as the plaster contracts with sufficient force to carry the plate with

it, the sides of the latter are approximated, while the palatal portion is, at the same time lifted up. Now it seems plain that inasmuch as the portions of plate overlapping the ridge is encased in and embraced by the plaster, and as the palatal portion is arched in form with its convexity presenting to the plaster and therefore self-sustaining in respect to its own peculiar form, the special configuration of these parts cannot suffer any appreciable change; but as they are forced toward the common centre of the mass, their *relation* to each other is alone changed, and this changed relation must necessarily eventuate in a deformity of those parts of the plate which offer the least resistance to the contractile force of the plaster. In obedience to this necessity, the sides of the plate along the sloping walls of the palate, which from their form are neither resistant or self-sustaining under pressure, and whose inward displacement is unopposed by any counter-force, is projected in toward the centre of the palatal excavation in proportion as the borders and central portions are approximated, or converge in the direction of the centre of the piece. The practical effect of this approximation of the lateral and posterior borders, and internal displacement of the plate, is to make the latter "bind" upon the outer and posterior borders of the alveolar ridge, and to throw the central portion of the plate from the roof of the mouth. To obviate, as far as practicable, any change in the form of the plate which may result from the contraction of the plaster investient, various expedients have been suggested, but the following will sufficiently counteract the influence of the plaster by permitting an unobstructed expansion and contraction of the metallic base. Take a band of tolerably thick copper plate as wide as the plate and teeth are deep; bend it to the form of the plate, but large enough to leave a space of nearly half an inch between it and the teeth, the ends being united to each other back of the plate by riveting or otherwise. Holes are then made in the band at numerous points throughout its extent, through which wire is introduced and interlaced on

the inside in such a way as to form loops,—the latter extending in to within a short distance of the teeth. The plaster is then filled into the space between the band and teeth even with the cutting and grinding surfaces of the latter; the palatal surface of the plate is also covered with plaster and may be connected with the outer portion by a very thin layer at the edge of the plate, or the two may be entirely disconnected. The expansion of copper being very nearly that of gold, the body of the plaster, when heat is applied, will be carried in advance of the borders of the plate as the latter expands, while the thin portion of plaster at the edges of the plate will allow the central portion of the latter to expand with but little or no interruption. On cooling, the entire mass will contract together and assume its original form, unless warping is induced by other agencies acting independently of the enveloping plaster, as excess or unequal distribution of solder, irregular heating, &c.

It is not, ordinarily, necessary to provide by any special expedient against warping of the lower plate, as any slight change of form consequent on contraction will not materially affect its adaptation to the lower jaw,—its only effect being to impart to the substitute a slight lateral play upon the ridge. The plaster on the inside of the lower piece may be cut away to the edge of the plate, while that external to the teeth should not be added in greater quantities than is barely sufficient to hold the latter in place whilst lining and soldering them to the base.

The plate being properly invested, all portions of the wax attached to the inner surface of the teeth and plate should be thoroughly removed with suitable instruments; after which stays are to be adjusted to the teeth. In reference to the method of forming and adjusting stays, little need be added to what has already been said when treating of partial dentures. One method not there specified, consists in first fitting to each tooth separately, in the usual manner, a thin stay formed of platinum, which is temporarily fastened to

the tooth by splitting and spreading apart the ends of the rivets with a small chisel-shaped instrument. The teeth are then removed from the investient and partially imbedded side by side in plaster, the platinum strips remaining uncovered. The plaster and teeth may then be raised to a full red heat with a blowpipe or by placing them in the furnace. Small pieces of gold plate, of equal fineness with the base, are then placed upon the surfaces of the platinum stays and thoroughly fused with the blowpipe until they flow perfectly in around the rivets, and uniformly over the surface of the linings. If sufficient heat is applied, the solder will insinuate itself between the stay and tooth, and thus render the coaptation of the two perfect. Small pieces of gold plate should be added until sufficient thickness is imparted to the linings. The backings are then trimmed smoothly and burnished, when they may be placed back in the investment in their appropriate places. The linings which support the teeth may be united to each other laterally in sections or continuously. When the teeth are joined to each other throughout, a very small quantity of solder will be sufficient to support the teeth, provided it is well diffused along the joints uniting them perfectly at all points.

The process of preparatory heating, soldering, pickling and finishing the plate, is the same in all respects as that described when treating of partial pieces, and need not, therefore, be recapitulated.

In the final adjustment of the finished pieces to the mouth, and after any additional grinding of the masticating surfaces of the teeth necessary to perfect the antagonism has been performed, such instructions should be given to the patient in regard to the care and management of the appliances as will best promote their immediate and successful use. The wearer should be impressed with the absolute necessity of early and prompt attention to any injuries inflicted upon the soft tissues of the mouth by the substitutes; as much future trouble and annoyance, if not permanent muti-

lation of the parts, may result from neglect, but which may be readily averted, in most instances, by a timely removal of the sources of injury. To obviate, in some measure, the tendency to displacement of the base, which usually accompanies the first use of artificial teeth, and especially the upper denture, the patient may be directed, when dividing food with the front teeth, to press the substance backward and upward against the cutting edges of the superior incisors at the same time that the opposing teeth are closed upon each other, thus dividing completely the substance seized. In reference to the mastication of food, it has been suggested to instruct the patient to distribute, by the action of the tongue, the portions of food as equally as possible on each side of the mouth, in this manner distributing the forces applied and thereby lessening the chances of lateral displacement of the substitute.

CHAPTER XII.

SUBSTANCES USED IN THE MANUFACTURE OF PORCELAIN AS APPLIED TO DENTAL PURPOSES.

SINGLE mineral teeth, porcelain blocks, continuous gum material, &c., are composed of two distinct portions,—the *Body* or *Base* and *Enamel.* The chief mineral substances which compose the body, are, *Silex, Felspar* and *Kaolin.* The enamel, both crown and gum, consists principally of *Felspar.*

The various tints or shades of color are imparted to the porcelain by certain metals in a state of minute division or their oxyds. The more general properties of the mineral ingredients will be first described.

Silex.—Silex, silica, or silicic acid, is a white powder, inodorus and insipid. It forms the chief part of many familiar mineral formations, as quartz, rock crystal, flint, agate, calcedon, and most sands and sandstones, in some of which it occurs nearly pure. Silica, in its pure state, is insoluble in water or acids, and is infusible in the highest heat of the furnace; it melts however in the flame of the oxy-hydrogen blowpipe, passing into a transparent colorless glass. Its specific gravity is 2·66; and is composed of silicon, 48·04, and oxygen, 51·96. Only the purest varieties of silex are employed in the manufacture of porcelain teeth. It is prepared for use by subjecting it to a white heat and then plunging it into cold water, after which it is ground to a very fine powder in a mortar.

Felspar.—This mineral substance occurs crystallized in oblique rhomboidal prisms, and is a constant ingredient of granite, trachyte, porphyry, and many of the volcanic rocks.

The felspathic mineral formations present either a pearly or vitreous lustre, and vary in color, being red, green, gray, yellow, brown, flesh-colored, pure white, milky, transparent, or translucent. Felspar yields no water when calcined; melts at the blowpipe into a white enamel, and is unaffected by acids. It is composed, according to Rose, of—silica, 66·75; alumina, 17·50; potash, 12; lime, 1·25; oxyde of iron, 0·75. It is found in various localities throughout the United States, the purest and whitest kinds being employed in the manufacture of mineral teeth. It is prepared for use in the same manner as silex.

Felspar, from its ready fusibility, serves to agglutinate the particles of the more refractory ingredients, silex and kaolin; and when diffused throughout the mass imparts to the porcelain a semi-translucent appearance.

Kaolin.—Kaolin, or decomposed felspar, is a fine white variety of clay, and is composed chiefly of silica and alumina, the latter being the characteristic ingredient of common clay. It is found in various localities throughout the Eastern States, and in parts of Asia and Europe. Kaolin is refractory or fire-proof, but is rendered more or less fusible by the contaminations of iron and lime with which it is usually combined. The opaque and lifeless appearance characteristic of the earlier manufacture of mineral teeth was due to the introduction of a relatively large proportion of this clay into the body of the porcelain. The peculiar translucent and life-like expression which distinguishes the beautiful imitations of the present day, is due, in great part, to the comparatively small proportion of kaolin clay, and an increased amount of the more fusible and vitreous component, felspar.

Kaolin is prepared for use by washing it in clean water; the coarser particles having settled to the bottom, the water holding the finer ones in solution is poured off, and when the suspended clay is deposited at the bottom of the vessel, the water is again poured off, and the remaining kaolin dried in the sun.

Coloring Materials.—The following metals and oxyds are employed in coloring mineral teeth ; titanium, platina sponge and oxyd of gold being those chiefly used in producing the more positive tints, and by combining which in varying proportions, any desired shade of color may be obtained.

METALS AND OXYDS.	COLORS PRODUCED.
Gold in a state of minute division,	Rose red.
Oxyd of Gold,	Bright rose red.
Platina sponge and filings,	Grayish blue.
Oxyd of titanium,	Bright yellow.
Purple of Cassius,	Rose purple.
Oxyd of uranium,	Greenish yellow.
Oxyd of manganese,	Purple.
Oxyd of cobalt,	Bright blue
Oxyd of silver,	Lemon yellow.
Oxyd of zinc,	Lemon yellow.

As the preparation of most of the above colors requires great care, and a somewhat intimate knowledge of chemistry, and as the most delicate manipulations are necessary to secure accurate and satisfactory results, it is better for the mechanical operator to procure the coloring ingredients already prepared from some competent chemist, rather than attempt their production himself. For a particular description of the various modes of preparing them, the reader is referred to Piggot's "Dental Chemistry and Metallurgy," and other works treating fully of the subject.

CHAPTER XIII.

PORCELAIN BLOCK TEETH.

The fabrication of porcelain block teeth constitutes a somewhat distinctive branch of practical dentistry, and from the delicate nature of the manipulations and long experience necessary to attain to any considerable degree of excellence in the various processes connected with their manufacture, their construction is seldom attempted by those engaged in general practice. A practical knowledge of the process, however, becomes, in some measure, indispensable on the part of those who cannot conveniently command the services of an experienced block-workman, inasmuch as cases are constantly occurring in practice, especially those connected with the replacement of partial sets of teeth, in which it is impossible to fulfill efficiently the requirements of the case with single gum teeth, but which may be accomplished in the most perfect manner by means of porcelain blocks constructed with special reference to the condition of the parts to be supplied. The process is applicable as well also, to full arches in the form of sectional blocks. In any case, the impracticability of readily or successfully repairing them when broken or otherwise injured, must always limit their use, in a great degree, to those cases that do not admit of other equally satisfactory means of substitution.

A description of the general properties of the several ingredients, earthy and metallic, used in the formation of block teeth, has already been given in the preceding chapter. The method of compounding and preparing the materials will next be given, with various approved recipes for body and enamel.

Composition and Preparation of the Body.—The porcelain paste for the body of block teeth may be compounded from either of the following formulas. There are a great variety of recipes, differing more or less in the proportion of the component ingredients, but the following will be found to answer every practical purpose, and are such as are generally employed at this time by experienced block-workmen.

NO. I.

Delaware spar,	12 oz.
Silex, . .	2 oz. 8 dwts.
Kaolin, . .	7½ dwts.
Titanium, .	18 to 36 grs.

NO. II.

Delaware spar,	16 oz.
Silex, . .	3½ oz.
Kaolin, . .	½ oz.
Titanium, .	20 to 60 grs.

NO. III.

Spar, . .	12 oz.
Silex, . .	2 oz. 8 dwts.
Kaolin, . .	12 dwts.
Titanium, .	24 grs.

NO. IV.

Spar, . .	8 oz.
Silex, . .	1½ oz.
Kaolin, . .	4 dwts.
Titanium, . .	22 grs.

NO. V.

Spar, . .	2 oz.
Silex, . .	8 dwts.
Kaolin . .	2 dwts.
Titanium, .	4 grs.

The titanium is first ground in a mortar until reduced to an impalpable powder; the silex is then added and ground from one to three hours, or until there is no perceptible grit; after which the kaolin is added and thoroughly ground; and lastly the spar, adding small portions at a time, and grinding the whole until perfect comminution and intermixture of the several ingredients are effected, say from half an hour to an hour. The ingredients may be ground dry or in water,—in the latter case a sufficient quantity of clean rain water should be added, from time to time, to form a mixture of about the consistence of thick cream. After sufficient comminution is effected, the surplus water may be abstracted by pouring the mixture upon a clean, dry slab of plaster of Paris. When it acquires about the consistence of thick dough, it should be beaten with a wooden mallet, or thrown repeatedly and

forcibly upon a marble slab, and, if prepared in quantities for future use, it should be preserved in its plastic state by confining it in a closely-stopped earthen jar. When ground dry, the materials are prepared for immediate use by adding to the powder clean rain water in sufficient quantity to form a thick paste; it is then well beaten on a porcelain or marble slab, and pressed, just before using, between folds of cloth to expel perfectly all particles of air that may be confined in the body of the paste.

Composition and Preparation of Crown Enamels.—The enamel, which forms the external covering to the crowns of porcelain teeth, is composed wholly of felspar with such coloring matters as serve to communicate to it the various tints or shades of complexion characteristic of the natural organs. The more positive tints, grayish-blue and yellow, are produced by titanium, platinum sponge, and oxyd of gold; intermediate colors being produced by varying the special combinations of these ingredients.

The following recipes will furnish various tinted enamels, the varieties of *grayish-blue* being applied to the points or coronal extremities of the teeth—the *yellow* to the necks; the two colors being so blended when applied as to run imperceptibly into each other.

GRAYISH-BLUE ENAMEL.

NO. I.		NO. III.	
Spar,* . . .	2 oz.	Spar, . . .	2 oz.
Platina sponge .	¼ gr.	Platina sponge, .	¾ gr.
Oxyd of gold, . .	½ gr.	Oxyd of gold, . .	½ gr.
NO. II.		NO. IV.	
Spar, . . .	2 oz.	Spar, . . .	2 oz.
Platina sponge .	½ gr.	Flux,† . . .	24 grs.
Oxyd of gold, . .	½ gr.	Platina sponge, .	½ gr.

* The Boston spar is preferred on aeeount of its greater fusibility.

† *Flux* is eomposed of silex 4 oz.; borax 1 oz.; sal tartar, 1 oz.; these are ground to an impalpable powder and packed in the bottom of a clean, light colored erueible. A piece of fire-elay slab is then fitted into the top of the erucible and luted with kaolin elay. It is then exposed to the heat of a furnaee until eompletely fused, when it is removed, and when eold the erueible is broken, all foreign particles or diseolored portions thoroughly removed, and the remainder well pulverized

YELLOW ENAMEL.

NO. I.		NO. III.	
Spar,	2 oz.	Spar,	2 oz.
Titanium,	10 grs.	Titanium,	16 grs.
Platina sponge,	½ gr.	Platina sponge,	½ gr.
Oxyd of gold,	½ gr.	Oxyd of gold,	½ gr.

NO. II.		NO. IV.	
Spar,	2 oz.	Spar,	2 oz.
Titanium,	14 grs.	Flux,	20 grs.
Platina sponge,	½ gr.	Titanium,	10 grs.
Oxyd of gold,	½ gr.		

In compounding enamels from the foregoing recipes, the coloring ingredients should first be ground to a very fine powder, with five or six dwts. of the spar; the remaining portions of the latter should then be added, a little at a time, and ground for half an hour or more. The shades of color may be varied almost indefinitely by changing the proportions of the coloring matter.

GRAYISH-BLUE ENAMEL.

NO. I.		NO. II.	
Spar.	1 oz.	Spar,	1 oz.
Blue frit,*	5 grs.	Yellow frit,†	4 grs.
		Gold mixture,‡	20 grs.

Composition and Preparation of Gum Enamels.—Either of the following recipes will furnish a good gum enamel, and may be used in connection with any of the compositions for body heretofore enumerated.

NO. I.		NO. II.	
Gum frit, No. 1,	3 dwts.	Gum frit, No. 2,	3 dwts.
Spar,	9 to 12 dwts.	Spar,	3 to 18 dwts.

* *Blue frit* is composed of spar, ½ oz.; platina sponge, 4 dwts.; powder very finely, make up into a ball with water, and fuse very slightly upon a slide in a furnace. It is then plunged into water while hot, and when dry, finely pulverized.

† *Yellow frit* is made by mixing intimately ½ oz. of spar with two dwts. of titanium. and heating as above.

‡ *Gold mixture* is prepared by dissolving 8 grs. of pure gold in *aqua regia*, and then stirring in 12½ dwts. of very finely pulverized spar. When nearly dry, it is formed into a ball and fused upon a slide, and then coarsely pulverized.

It is recommended, in order to impart a granular appearance to the gum, to grind the spar somewhat coarsely; any required shade or depth of gum color being obtained by varying the proportions of the frit,—the latter containing the coloring ingredients.

Gum Frit, No. 1, is composed of felspar, 700 grs.; flux, 175 grs.; oxyd of gold, or metallic gold in a state of minute division, 16 grs.

The above are ground in a mortar for five or eight hours, or until they are reduced to an impalpable powder; they are then packed in the bottom of a clean Hessian crucible coated on the inside with a thin mixture of pulverized silex, and on the outside with kaolin. A piece of tile or slab is then luted with kaolin to the top of the crucible, when it is placed in the furnace for from one to two hours, or until complete vitrification is effected. It is then removed, and when cold, the crucible is broken and all traces of adhering silex ground off; it is then broken in pieces and ground until it will pass through a sieve, No. 9, bolting cloth.

Gum Frit, No. 2, is composed of spar, 700 grs.; flux, 175 grs.; purple cassius, 8 grs.

The purple cassius is first thoroughly ground in a mortar, after which the flux is added in small quantities at a time, then the spar in the same manner, grinding until perfect comminution and intermixture of the several ingredients are effected. It is then packed tightly in the bottom of a clean white crucible, the inside lined with silex and a slab luted to the top, as before, and the whole exposed to a heat sufficient to fuse perfectly. It is then removed from the fire, and when cold, all foreign substances are ground off and the remaining portions pulverized until it will pass through a sieve of No. 9, bolting cloth.

Having given the composition and mode of preparation of the various compounds which enter into the formation of the body and crown and gum enamels, it only remains to describe the different processes concerned in the construction of

porcelain blocks from the several compositions given, and first of the method of procuring an antagonizing model.

Antagonizing Model for an Entire Upper and Lower Denture constructed of Block Teeth.—The first step in the process of constructing block teeth, for either a full upper set with the natural teeth of the opposite jaw remaining, or for entire dentures for both jaws, is to secure an antagonizing model. For the latter or complete dentures, above and below, the method does not differ from that employed when single gum teeth are used. A rim of wax is adjusted to each plate in the manner heretofore described, and the plates placed in their proper position in the mouth; the wax drafts are then trimmed until the exact fullness and contour of the lips and cheeks are secured and proper relative width is given to the wax rims. Great exactness should be observed in these latter manipulations, inasmuch as the wax drafts are the only guides in the formation of the blocks, both as respects the form and fullness of the arch and the length of the teeth. The proper relation of the two pieces in the mouth is now secured, the wax rims attached to each other, and the median line of the mouth indicated on the wax, and being removed from the mouth, an antagonizing model procured in the same manner as described in a former chapter.

Antagonizing Model for an Entire Upper Denture with the Natural Teeth of the opposing Jaw remaining.—A rim of wax, half an inch or more in width, is attached to the ridge of the plate and the latter placed in the mouth. The patient is then directed to close the jaws until the cutting edges and grinding surfaces of the teeth of the opposing jaw are fairly imbedded in the wax. The piece is then removed from the mouth and the wax rim detached from the plate by holding the latter for a moment over a spirit-flame. The wax is then placed upon a strip of paper with the side indented by the teeth looking upward, the surface of the wax oiled and a batter of plaster poured upon it, filling the imprints of the

teeth and running back an inch and a half or more behind the wax, raising the plaster to a level of half an inch above the wax. When the plaster is sufficiently condensed, it is turned over, the wax removed without fracturing the plaster teeth, and a crucial groove made in the surface of the model posterior to the teeth. This constitutes the lower section of the antagonizing model, and is a representation of the teeth of the lower jaw. The upper section is next obtained in the following manner. A second rim of wax, in width equal to the required length of the teeth, is adjusted to the plate as before and placed in the mouth. The exact contour and fullness of the arch required is then given to the external or labial surface of the wax draft, and the lower edge cut away until the required approximation of the jaws is secured and the points of all the teeth remaining below touch the wax at the same instant. The patient is now required to close the jaws gently upon each other until a slight indentation is made in the wax by the opposing teeth; the median line of the mouth is then marked upon the wax and the plate removed. The plate and wax are now adjusted to the lower section of the model, the points of the plaster teeth being received into the indentations in the wax made by the natural teeth. The upper and posterior surface of the lower section of the model having been varnished and oiled, and the exposed surface of the plate also oiled, a mixture of plaster is poured in upon the latter and back upon the model, raising the whole to a level of half an inch above the plate. The two sections, when the latter portion of plaster has consolidated, are then separated, reserving the lower part of the antagonizing model for future use.

Forming a Matrix for Molding the Body preparatory to Carving the Teeth.—As the process of forming a matrix in which to mold the porcelain paste, giving the general form and outlines to the blocks before carving the teeth, is the same for an upper and lower denture, it will be sufficient to describe the method as it relates to the superior arch. A

matrix for an entire denture above or below, whether consisting of three, four, or six blocks, is ordinarily made to consist of three distinct pieces independently of the plate and model, and is constructed in the following manner. Three conical-shaped holes are made in the sides of the model, one in front and one on each side, to furnish a fixed articulation for the three sections forming the external walls of the matrix. The appearance of the model when thus prepared, with the plate and wax rim in place, is exhibited in Fig. 86. The sides of the model and external face of the wax are now oiled, and both surfaces covered with a batter of plaster to the depth of a fourth or a half of an inch, extending from the base of the model to the lower edge of the wax, and posteriorly about half way on each side of the model to form a matrix for the front block, or the two anterior blocks, if the arch is made to consist of more than three sections. Supposing the wax removed from the plate and this front piece in place, the several parts will present the appearance shown in Fig. 87. The plaster rim forming the external wall of the front block being removed, plaster is again added, as before, to the outer surfaces of the model and wax, extending it from the heel of the plate on each side forward an eighth or a fourth of an inch in advance of the posterior extremities of the plaster rim first formed. When hard, the plaster is trimmed even with the edge of the wax draft, and the two pieces removed from the model. The matrices formed by these lateral sections when readjusted to the model with the wax removed are shown in Fig. 88. Having thus provided

FIG. 86.

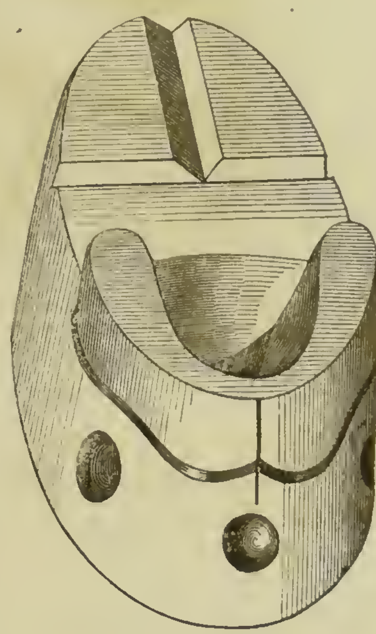
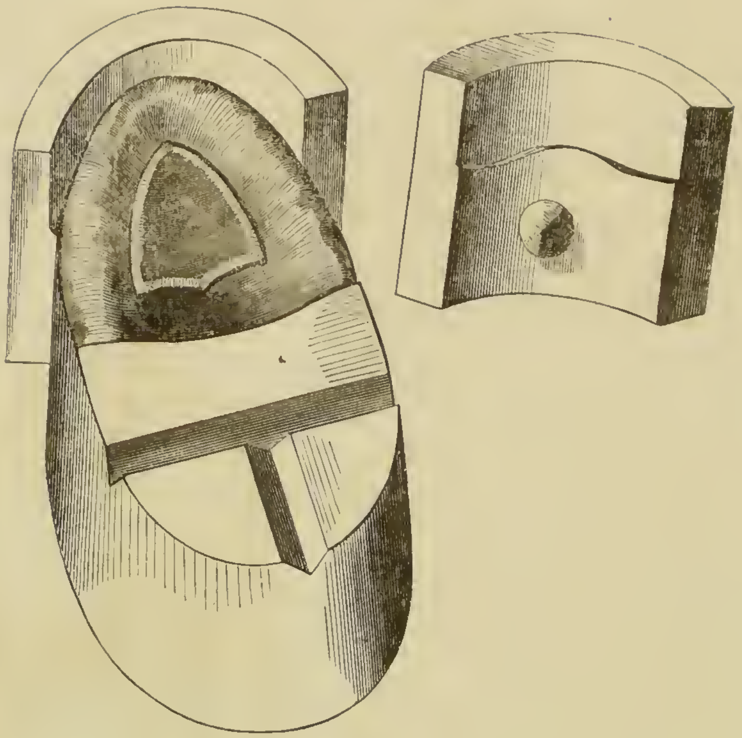


FIG. 87.



a matrix determining the general outline and length of the teeth for the entire arch, the wax draft is removed and the

FIG. 88.

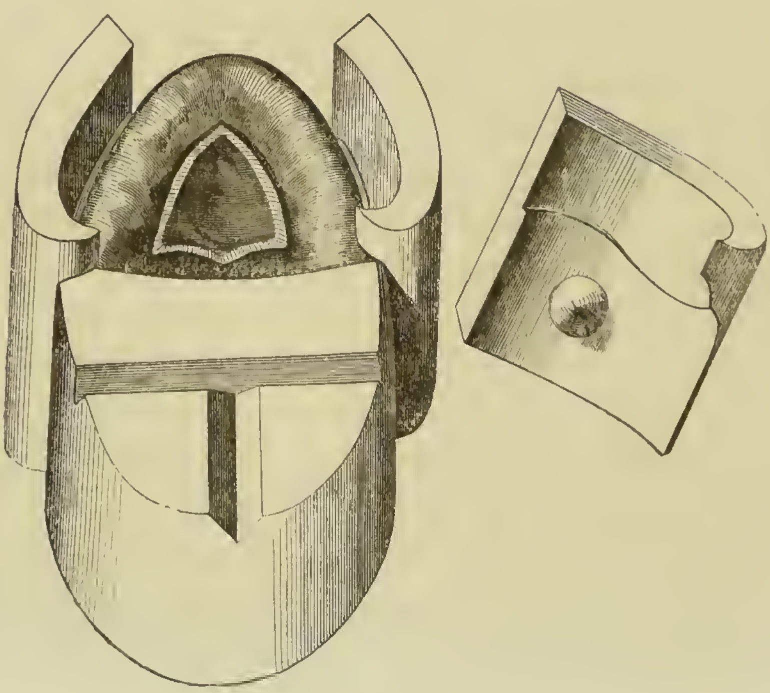


plate thoroughly cleaned preparatory to molding the paste,—before doing which, however, the line upon the wax indicating the median point of the mouth should be extended across the model.

Molding the Porcelain Paste preparatory to Carving the Teeth.—In the process of constructing an entire denture, it is impracticable, owing to the shrinkage of the body, to form a single continuous block or full arch without materially changing its relation and adaptation to the metallic base, and also to the natural organs in cases where the latter are remaining in the opposite jaw; hence it is customary, as before intimated, to divide the arch into sections,—usually three; a central front block embracing the incisors and cuspidati, and two lateral blocks including the bicuspids and molars on each side; or the denture may consist of four blocks, dividing the arch between the central incisors, and also between the first and second bicuspids on each side; making the two anterior blocks to consist each of a central and lateral incisor, a cuspidatus and anterior bicuspid, and the posterior blocks of the second bicuspid and the two molars. Again, the arch is sometimes divided into six blocks,—an anterior embracing the central and lateral incisor and cuspidatus, a central comprising the bicuspids, and a posterior including the molars. If constructed in three sections, as is ordinarily the case, the front block should be molded and carved first. The material for the body, if in a dry state, is mixed with a sufficient quantity of clean rain water to form a thick batter, and mixed thoroughly in a mortar. It should then be poured upon a dry slab of plaster of Paris, and when the excess of water is absorbed, removed and well beaten with a spatula on a marble or porcelain slab until it assumes a somewhat pasty form; it may then be well pressed between folds of cloth to force out any remaining portions of confined air. The plaster rim forming the matrix for the front block is now adjusted in its proper position to the model, and its inner surface, as well as that of

the plate, oiled; the porcelain paste is then packed into the matrix as compactly as possible, filling it even with the upper edge of the plaster rim. When the paste has been worked in as solidly as possible, patting it with the fingers or suitably formed instruments as successive portions are added, it should be trimmed even with the edge of the plaster rim and the palatal surface cut away to near the thickness required for the teeth included in the block, leaving it somewhat thicker, however, to compensate for the shrinkage of the body, and to allow for small portions which will be cut away in carving the teeth. The plaster rim forming the external border of the matrix is now loosened by tapping gently upon the model and then carefully removed. The mark upon the model, showing the mesial line of the mouth and indicating the proper position of the central incisors, is then extended across the block, after which the width of each adjoining tooth is lined off, making each one as much broader than will be required in the finished piece as the porcelain composition will shrink in baking,—this, in a block embracing the six anterior teeth, will be equivalent to about one-third or one-half the width of a bicuspid on each side. If the case is one requiring a full denture above and below, the operator should next proceed to mold the front block for the lower arch in the same manner as described for the upper. The two sections of the antagonizing model are then placed together, and the proper relative width for the lower teeth indicated upon the inferior block,—the drawn lines upon the upper block serving as a guide. The points to which the posterior extremities of the front block extends on each side of the plate should be marked upon corresponding points of the model above and below to enable the manipulator to determine how far the side blocks should be extended anteriorly when molding the paste for the latter,—the marks upon the model being subsequently transferred to the lower edges of the lateral sections of plaster concerned in the formation of the side matrices. Before removing the

front blocks from the plates preparatory to carving the teeth, the surface of the paste may be dried somewhat by throwing upon it, with a blowpipe, a broad spreading flame from a spirit lamp. The blocks are then carefully detached by rapping lightly upon the model, assisted by gentle traction with the fingers. The front blocks being removed from the upper and lower plates, the side sections of plaster concerned in the formation of the posterior matrices are adjusted to the model, and, being oiled, the paste filled in as before described, extending each block forward beyond the point occupied by the cuspidatus of the front block a distance equal to about one-third or one-half of the width of the latter. These are then cut away even with the edges of the plaster rims and trimmed on the palatal sides, leaving them somewhat thicker than will be required for the bicuspids and molars. The plaster walls of the matrices are then removed; the two parts of the articulating model placed together, and the relative width and position assigned to the upper and lower teeth by drawing lines across the external surface of the blocks. They are then separately removed from the plates in the manner before described, and the necessary additional portions of paste added to the grinding surfaces to compensate for the contraction of the body in baking. In constructing a full upper denture with all or a portion of the natural organs remaining below, the proper width to be given to the upper teeth, as well, also, as the required relation or antagonism of the artificial with the opposing natural teeth, may be readily determined by applying the lower portion of the antagonizing model representing the teeth of the under jaw, and marking upon each block, as it is being molded, the necessary width and position of each tooth above,—being careful to make allowance for shrinkage by adding to the length, width and thickness of each block as much as will compensate for the contraction of the body. In every other particular, the process is conducted in the same manner as heretofore described.

Carving the Teeth.—The teeth are first separated by drawing between them a thread attached to a small bow, and it may be observed in this connection that the most careful and delicate manipulation is required in handling the blocks while carving to prevent portions of the paste from crumbling away, a tendency that may be counteracted, in some measure, by moistening the paste occasionally with a little water taken up on the point of the carving knife. The general outline of each tooth having been traced upon the exterior surface of the block with the point of the instrument, the operator proceeds next to give the distinct and characteristic form to the crowns, and the harmonious and agreeable effects produced will depend upon the fidelity with which the manipulator copies nature in the form and arrangement of the teeth. The requirements of individual cases are too varied in their nature to admit of specific directions in respect to their formation,—a careful study of the modified forms of the natural organs, combined with some degree of manipulative tact, will enable any one, after sufficient experience, to attain to satisfactory results in this particular. After the teeth are formed, and the body of the block is reduced to the required thickness, superfluous portions extending from the ends of the block should be cut away, leaving enough, however, projecting to allow for grinding when jointing and adjusting the several blocks to the metallic base. Fig. 89 exhibits the general form of the blocks when carved, showing also the platinum pins, but which are not usually attached to the blocks until after the latter are first biscuited.

Fig. 89.

Crucing, or Biscuiting.—The blocks being carved, are next placed on a fire-clay slab with their palatal surfaces resting on a bed of silex. As soon as the paste has become thoroughly dry, the slab may be gradually introduced into the muffle of a baking furnace, (Fig. 11,) and exposed to a

full red heat until semi-fusion of the body takes place. This partial vitrification of the body serves to agglutinate the particles of the compound and is termed *crucing* or *biscuiting*. When removed from the furnace, and cool, the platina pins should be introduced into the blocks before applying the gum and crown enamels, and is accomplished in the following manner. One or two small holes, as the case may require, are drilled into the body of the block immediately behind and below the crown of each tooth, extending about half-way through the block; into these, platinum pins or wires are introduced, a head being formed to the end of the pin entering the block. A small portion of the body composition, mixed with water to the consistence of thin cream, is then worked into the hole around the pin with a sharp-pointed carving knife or camel's-hair brush, its introduction being facilitated by first immersing the block in water immediately before inserting the pins.

Application of the Crown and Gum Enamels.—The gum enamel is applied first, the material being first prepared by mixing the gum composition with sufficient clean rain water to form a batter of about the consistence of thin cream. This is then taken up with a camel's-hair brush and applied uniformly to all parts of the external surface of the block representing the natural gum. It should be applied very carefully to the necks of the teeth, forming a neat and well-defined festoon at these points. In applying the crown enamel to the labial surfaces of the teeth, it is customary, in imitation of the natural organs, to so distribute the more positive tints as to give to that portion of the crown representing the neck of the tooth a somewhat yellowish hue, and to the points, a grayish blue tint. To effect this, the material for the yellow enamel, reduced to the consistence before mentioned, is first applied to the necks, uniting it carefully with the gum enamel; and afterwards the grayish-blue to the points, extending it a little below the cutting edges of the incisors, and the cusps of the cuspidati, bicuspids, and molars, giving

to the teeth, at these points, a translucent appearance. It is only the external and lateral surfaces of the teeth that are enameled, the palatal surfaces remaining unglazed. The yellow and blue enamels should be so blended when applying them to the crowns that the one shall fade away imperceptibly into the other.

Final Baking.—The enameling completed, the blocks are placed upon a bed of silex on a slide, and the latter carefully and slowly introduced into the mouth of the furnace. The fire should then be urged to a clear white heat, and when perfectly dry, the blocks should be carried with the slide into the body of the muffle, and the mouth of the latter closed tightly with a fire-clay plug. Some knowledge of the requisite degree of heat and time necessary to effect perfect fusion of the ingredients composing the blocks is required, and these are ordinarily well known to experienced block-workmen, but those unaccustomed to the process will better determine the completion of the baking by introducing into the muffle along with the blocks a small portion of the body covered with enamel attached to one end of a platinum wire, the other passing through a small stopper fitted to the centre of the plug closing the end of the muffle, and which may be removed and the wire withdrawn from time to time to observe the effect of the heat upon the test piece. When this is seen to be perfectly fused, as evidenced by a uniform glossiness of the surface, the slab should be drawn to the mouth of the muffle, the draft cut off, and the blocks allowed to cool gradually with the furnace. In place of using a test piece, however, it will answer the purpose to withdraw the slide to the mouth of the muffle occasionally, where it may be readily inspected and the progress of baking noted. When sufficiently cool to be taken in the hand, the blocks are removed from the furnace.

Fitting and Attaching the Blocks to the Metallic Base.—On applying the blocks to the plate, it will be found that a greater or less change of relation between the two has occur-

red in the process of baking, so that the base of the former will not fit the portion of the plate on which they rest as accurately as when first molded. It will, therefore, be necessary, when adjusting each block, to grind away somewhat from the base of the latter until the coaptation of the two surfaces is as perfect as practicable. The several blocks should also at the same time be accurately united to each other laterally, grinding away from the ends, and approximating the sections as the articulation of the opposing dentures may require to effect a proper and efficient antagonism, and which may be determined by the use of the antagonizing model employed in molding the blocks. After the blocks are fitted, and the teeth antagonized, and before uniting the former permanently to the plate, a rim should be formed and attached to the borders of the metallic base to form a socket for the plate extremities of the blocks, and which, extending around the margins of the plate, should be continued across the heel of the latter on each side and made continuous with the band or lining on the palatal sides of the teeth. The manner of forming and attaching the rim does not differ from the method heretofore described in connection with full dentures constructed of single gum teeth, and to which the reader is referred. The rim fitted, and the blocks replaced, the whole is invested in the usual way, the wax removed from the plate, and a continuous band or lining adjusted to each block. The latter is accomplished by first cutting a pattern of the band from sheet lead of the length of the block, and of the required width, trimming the edge applied to the plate in such a manner that when adjusted to the backs of the teeth it will lie in uniform contact with the base; this is then pressed against the pins with sufficient force to perforate it. The lead pattern is then placed upon a strip of gold of the required thickness, and the counterpart of the pattern cut from the gold plate, marking at the same time the points to be perforated for the platinum rivets. This is then pierced with a plate-punch, and the strip bent to

the proper curve and applied to the block, when it is bound to the latter by splitting and spreading apart the ends of the rivets. A band is thus applied to each block. Solder is then applied along the joints, and over the pins, and all parts united with the blowpipe in the usual manner. The piece is then finished up the same as ordinary gold work. Fig. 90 exhibits a palatal view of an upper set of block teeth mounted on a metallic base. When skillfully executed, the finished work presents a beautiful and highly artistic appearance. The application of sectional porcelain blocks to the necessities of mechanical practice is being greatly extended in connection with the "Vulcanite base," and, to a more limited extent, with the "Cheoplastic" method of mounting teeth. Their construction, however, is modified somewhat by the requirements of these special processes, and as made for the latter, are of such approved manufacture, and are supplied in such abundance and at so reasonable a cost by all the principal dental furnishing establishments, that the general practitioner, we apprehend, will ordinarily find it more convenient and economical to purchase rather than manufacture them himself.

Fig 90.

The subjoined account, descriptive of a new method of making block teeth, by Dr. William Calvert, was inadvertently omitted in the former edition of this work. The process has received marked commendation by competent persons who have investigated its merits, and will be highly esteemed by those who desire to excel in this beautiful but difficult art.

"The first preparatory step to be taken, after having correct articulating models, is to select single teeth so defined as may either suit the taste of the operator or the peculiarity

of the case, and supposing the case to be an upper denture, it will be necessary to have *two* front and two lateral incisors, two canine or cuspids, two bicuspids, (or if more convenient the cuspids,) and four molars, all of which should be sufficiently large to compensate for shrinkage, in the material of which the teeth are to be composed.

"The plate upon which the blocks are to be made, and to which they are to be subsequently fitted, being upon its corresponding model, a rim of wax may be placed upon it, and the teeth arranged upon the wax, articulating with the antagonizing model, allowing sufficient in the length of the teeth for shrinkage. Beginning with the front incisors, the teeth should be set to the wax (as above) as far back on each side as the first bicuspids, inclusive; then leaving a space equal to the width of *half a tooth*, the arch may be completed by the addition of the molars, two on each side. The teeth having been thus arranged upon the wax, with reference to regularity or irregularity, height, etc., the desired outline of gum may be filled up with wax.

"Special care is requisite in so trimming the wax where joints are contemplated, that no subsequent alteration will be needed during the further manipulations.

"It will be necessary, previous to making the molds, to make some provision for replacing them, after they have been once removed, so that they shall occupy the same position as they did previous to their first removal. For this, it will be only necessary to make some conical holes in the face of the cast, say two on each side, between the centre and the first bicuspid teeth, and two opposite the molar teeth of each side. These holes need not be more than about a quarter of an inch deep, and should be but a short distance below the edge or line of the plate. The face of the cast, including said holes, should now be varnished, when the case is ready for making the molds.

"The first mold to be made should be that including the four incisors, two canine, and two first bicuspids, eight teeth

in all. This may be done by simply oiling the face of the teeth, outline of gum, and plaster cast, and pouring plaster of Paris of a proper consistency over the surface of the same, allowing it to fall slightly over the cutting edges, so as to form a more perfect mold. This mold should be divided in the centre, making two sections, which can be done by cutting through the plaster while in the state of hardening; or, what is perhaps better, before applying the plaster, make an incision in the wax outline of gum, in which place a thin slip of sheet lead, letting it extend a little above the cutting edges of the teeth, and as far down the face of the cast as is desired to extend the mold. When hard, remove from the cast and teeth, and we have the untrimmed mold for said eight teeth. Previous to making the molds for the back teeth, it is necessary to remove the *first* bicuspids, or the cuspids representing them, from the position they occupied in making the mold just described, and placing them beside the first molars so as to represent the *second* bicuspids. Care is to be taken in removing and replacing them, so that the original form of the wax be preserved, otherwise the end thereby intended to be secured will be defeated, and the joints at these points will be irregular and unsightly.

"For the purpose of rendering clear a point necessarily left somewhat obscure in the foregoing description, it may be well here to state that the space of *half a tooth*, left between the first bicuspids and the first molars, *is* to compensate for shrinkage in the length of the arch, for after the first bicuspids are removed and set adjacent to the first molars, thereby representing the second bicuspids, they occupy the entire vacancy first left and one-half the space formerly occupied by said first bicuspids; hence the extension of the back molds toward the centre is equivalent to the shrinkage of the entire arch.

"As the foregoing is applicable where the case of fourteen teeth is to be divided into four blocks, as is usual in soldering, I would say that when the intention is to make pin

holes for riveting, the space of *half a tooth* must be left between the canine and bicuspids, instead of between the bicuspids and molars.

"The molds for the back teeth may now be made in the same manner as those of the front ones. After the molds have been made as already described, they should be so trimmed that in the process of molding the blocks there would be no liability of removing portions of the enamel off the teeth in withdrawing the molds. The molds should now be varnished with some spirit varnish, and after it becomes dry are ready for use.

"The molds being prepared, the next step is the enameling of the teeth in the molds. The enamels should be moistened with a little clean water, and having previously oiled the section or sections of the mold, the blue or point enamel may be first applied (as stiff as it will work) with a very small spatula made for the purpose. This enamel should be *thin* at the base, and gradually thickening with the concavity of the mold to the cutting edges of the teeth. The yellow or base enamel is next applied *heavy* at the base, and gradually terminating near the point.

"After the enameling has been completed so far as is designed to be molded at one time, a small quantity of the body about the consistency of a thick paste may be spread over the surface of the molds and of the enamels, the molds replaced upon the model, and the body carefully filled in, at first rather soft, but subsequently harder and harder, until the mold is sufficiently full. Then applying the flame of a spirit lamp for a few minutes with the blow-pipe, the body will be toughened enough to work well, when the molds may be removed. The teeth may then be separated and trimmed, the blocks divided as desired, the *gum* enamel applied, etc., etc., and so completed.

"The process of enameling and molding being precisely the same with all the blocks, it needs not that I should go into further detail.

"I have already said, that when the blocks are intended to be riveted upon the plate, the molds are required to be somewhat different. There is also another difference; that is, the molding of the pin or rivet holes, which may be done by removing the plate from the model, placing the molds upon the model, and drilling a small hole upon the prominence of the ridge opposite the centre of each tooth, in which insert a piece of wire of a desired size. The enameling, etc., may then be done as before described, and after the body has been hardened sufficiently, the pins may be removed, leaving the holes neatly molded, perfectly smooth and straight. The blocks may then be finished at once, before removing from the cast."

CHAPTER XIV.

UNITING SINGLE PORCELAIN TEETH TO EACH OTHER AND TO A METALLIC BASE WITH A FUSIBLE SILICIOUS COMPOUND, FORMING A CONTINUOUS ARTIFICIAL GUM.*

THE process of uniting single mineral teeth to each other and to a metallic base by means of a porcelain cement, was attempted as early as 1820, by Delabarre, of Paris, France, but with such imperfect and unsatisfactory results as induced its early abandonment. At a later period, Dr. John Allen, a distinguished practitioner of dentistry in America, devised a method embracing original and important modifications of practice both in the preparation and combination of materials, and the modes of manipulating them; and after an extended series of experiments, commencing in 1844, succeeded in obtaining certain mineral compounds which vitrified at a heat much below that employed by Delabarre, and the contraction of which corresponded so nearly with that of the platina base to which it was applied, that the shrinkage inci-

* The attentive reader of the first edition of this work will not fail to note that the statements involving the question of *priority*, contained in the introductory portion of the above chapter, are at variance with those originally published. A more extended examination and careful analysis of the evidences as they appear upon record—evidences not fully accessible to the author at the time of the publication of the first edition—establish beyond reasonable doubt the just claims of Dr. Allen as the originator of that special and distinctive method here considered by which the attachment of the teeth to the plate is effected by direct fusion of the gum material. Dr. Hunter's earliest and cotemporaneous experiments contemplated simply a union of all the teeth, by means of a fusible cement, forming a single, continuous block, which was afterwards united to the base by riveting or soldering.

This brief explanation is here introduced as an act of simple justice to Dr. Allen, who has devoted the best energies of his life to the successful development of a process which stands unrivalled in all the chief requisites of an artificial denture.

dent to baking conflicted, in no material degree, with the practical utility of the work in the mouth.

In the construction of dentures upon this principle, plain single teeth, made for the purpose, are arranged and soldered to a plate properly fitted to the mouth, after which different mineral compounds, made to represent the natural gums, roof, etc., are applied to the plate and teeth in a plastic state, then carved and trimmed in proper form, and by means of a strong furnace heat, these compounds, which are called the body and the gum enamel, are fused, thus producing a continuous gum, roof and ruga of the mouth, without seam or crevice.

The compounds at present employed in this process, as well as the more fusible preparations used for repairing purposes, are now manufactured by Dr. Allen in quantities sufficient to meet the wants of the profession, and may be procured at all the principal dental furnishing houses throughout the United States.

The intimate but later identification of Dr. W. M. Hunter with the above process has rendered his name familiar as one whose skill and devotion to this specialty of mechanical practice has contributed to its development in a modified form. Dr. Hunter's formulas and modes of manipulating his compounds, will be introduced, as published by him in 1852, at the conclusion of the chapter.

Before introducing an account of Dr. Allen's modes of procedure, the author would premise that it is unnecessary to repeat in this connection what has already been fully described in regard to impressions of the mouth, or the manipulations connected with the formation of plaster models and metallic swages; these processes being essentially the same as in the construction of ordinary gold work. Whenever a rim is to be formed to the border of the plate extending from heel to heel of the latter, and this is to be accomplished by swaging, the model should be shaped as described in connection with Fig. 27. If it is designed to enamel the

entire lingual surface of the plate, (a method now commonly practiced,) the shoulder upon the model should be extended across the heel of the latter from each extremity of the ridge on a line with the posterior border of the hard palate, to form a groove in swaging similar to, and continuous with, that on the outside of the ridge. The edges thus turned in swaging will flare more than is required,—the operation must, therefore, be completed by carefully turning them over sufficiently with the pliers. In place of swaging the rim, however, it may be formed by fitting and soldering along the border a narrow plain strip of platinum, extending it as before, if desired, across the posterior edge of the plate. Or a triangular piece of wire may be soldered on, beveled somewhat so as to overhang the base slightly, thus forming a shallow groove. The border to the palatal portion of the gum at the heel of the plate is sometimes formed in swaging by adjusting a wire across the heel of the model, which will be transferred to the plate in the form of a ridge. The latter should be raised a line or more from the posterior border of the plate, and should incline gradually to the edge, while the anterior surface should present an abrupt shoulder to the margins of the gum enamel.

The process of forming the rim is sometimes deferred until after the first portion of the body is baked, and before the gum enamel is applied. In this case, the borders of the plate, to the depth of from a line to a line and a half, are left uncovered by the base; after the latter has been baked, the uncovered margins are turned over upon the body with pliers and burnisher, and the gum enamel afterwards applied flush with the edge or surface of the rim.

In whatever way the rim or socket is formed, it is practically of the first importance that the exact dimensions of the plate required should be ascertained before the groove is formed, as it will be impossible to subsequently diminish the extent of the borders without, to some extent, impairing the integrity of the finished work. The mouth, therefore, should

be carefully examined, and the precise location, extent, and fullness of the muscles and integuments along the external borders of the ridge above and below, the glands underneath the tongue, and the extreme boundaries of the hard palate, carefully noted and accurately traced upon the plaster model to serve as a guide in determining the dimensions of the plate.

Additional strength will be imparted to the metallic base by doubling the central portion of the plate as described in Chapter XI. The following additional remarks on the method by Dr. Hunter are introduced.

"Platina as usually applied I think objectionable, wanting stiffness; my method of using it is similar to that proposed by Delabarre, but possessing greater strength than even his method, and by it can be made as light as a good gold plate got up in the ordinary way. I first strike a very thin plate to the cast, and cut out a piece the size of the desired chamber, taking care not to extend it forward to embrace the palatal artery. Add wax to the plate for the depth of the cavity, diminishing it neatly as it approaches the alveolar ridge. Cement this plate to the cast and take another metallic cast, strike another thin plate over the whole, and solder throughout with an alloy, of gold twenty-two parts, platina two parts, or with pure gold. The chamber thus formed is precisely the same as "Cleveland's Patent Plate," but the space *between the plates*, for which he obtained his patent, is subsequently filled up, leaving a cavity resembling Gilbert's, but with a sharper edge when so desired. This space is filled up with base and enamel, and gives great stiffness without the ugly protrusion of the struck chamber. The plate thus formed assimilates much more closely to the palatal dome, not interfering with pronunciation; another great advantage gained by it is the impossibility of warping. I say *impossibility*, because I have submitted plates so constructed to the severest tests, and never had them to warp. It is well to rivet the two plates together before proceeding

to solder, especially gold plates, and to bring the heat carefully upon them; once prepared there is no danger of change in the succeeding manipulations."

Dr. Allen's Modes of Practice.—The following descriptions, contributed by Dr. Allen, embrace a clear and concise account of the manipulations at present practiced by him in the construction of artificial dentures, with continuous gums.

"The plate or base is formed of platinum, or platinum and iridium. The plate being properly fitted to the mouth, and wax placed upon it for the bite, as in ordinary plate work, the teeth are arranged thereon, with special reference to the requirements of the case. They are then covered with a thin coating of plaster mixed with water to the consistence of cream. After this has become firmly set, another mixture of plaster and asbestos with water, somewhat thicker or more plastic than the first, is placed round on the outside of the previous covering and the plate. A convenient way of applying the second covering is to turn the mixture out of the vessel upon a piece of tin, say four or five inches square, thus forming a cone upon which the plate with the teeth upward, is pressed gently down until within an inch or less from the tin. Then with a spatula the mixture is brought up over the teeth, forming an investient that will not crack in the process of soldering. Sand may be used with the plaster for this purpose, but I think asbestos preferable.

"When the covering has become sufficiently hard, the wax is removed, and a rim of platinum is then fitted to the lingual side of the teeth, below the pins, and to the base plate. The pins in the teeth are then bent down upon the rim, and soldered with pure gold, or a mixture of gold and platinum, at the same time the rim is soldered to the plate. This rim, which forms the lining for the teeth, is usually about the thickness of the plate upon which they are set, say 28 to 30; but should the case require more than ordinary strength, a double or triple thickness of rim should be used. This may become necessary in cases where the natural molar teeth are

standing firmly in the opposite jaw, and antagonize with the artificial piece, or where from any cause an undue strain is brought to bear upon the artificial teeth. To attain successful results, the dentist must take into consideration all the circumstances or conditions of each particular case, and then exercise his best judgment in executing the work.

"In soldering platinum with pure gold, flat surfaces of this metal should be brought in positive contact, in order to become firmly united. Therefore in mounting teeth upon a plate of this kind, the backing or inside rim should be a little wider than the distance between the pins in the teeth and the plate, say from an eighth to a fourth of an inch. This extra width of rim should be bent at right angles along the base of the teeth so as to admit of being pressed down upon the plate after the rim is adjusted to the teeth, and the pins bent down firmly upon it. In this way flat surfaces of the rim and plate are brought together and soldered. The pins in the teeth are also soldered to the rim at the same time. When the parts are thus united, they will remain so during the subsequent bakings; but if the edge of the rim only is fitted to the plate and soldered like gold or silver work, the subsequent heatings for baking the body and gum will cause the gold to become absorbed in the platinum, and leave the joints not united. It may be asked why not use common gold solder for this style of work? Answer, because the alloy in the solder will greatly injure the color of the gum enamel in baking. Copper alloy will turn it to a greenish shade, and silver will give it a yellow tinge. Although pure gold requires more intense heat to melt it (being about two thousand degrees), than ordinary gold solder, yet when melted it flows much more freely than the latter. The best way to solder the teeth upon platinum plate is, to place small pieces of gold upon the joints or parts to be soldered, with wet ground borax, and then slowly introduce the piece with the investient into a heated muffle, and bring the whole mass up to a red heat; then withdraw it from the furnace, and bring

it quickly under the blow-pipe to flow the gold. In this way the teeth do not become etched, as they are liable to be if the soldering is done in the furnace.

"The piece being soldered and cooled, the covering is removed from the teeth, taking care to preserve the base unbroken for the plate to sit upon during the subsequent bakings of the body and gum enamel.

"All particles of plaster or other foreign matter should be removed from the teeth and plate by thoroughly washing and brushing them. It is well to immerse the piece for a short time in sulphuric acid, after which rinse and brush it well with water. This done, a colorless mineral compound, called the body, is applied in a plastic state (with spatulas or small instruments for the purpose) to the teeth and plate. It is then carved to represent the gum, roof and ruga of the mouth, taking care to keep the crowns of the teeth well defined. The piece is then placed on the base upon which it was soldered and set upon a slide on the apron in front of one of the upper muffles of the heated furnace,—and every eight or ten minutes it should be moved forward into the muffle, say two or four inches each time, until the piece shall have passed the centre of the same, which should be at a red heat. It is then withdrawn and passed into a lower muffle where the heat is greater, in which the body soon becomes semi-vitrified, which is sufficient for the first bake. It is then taken out and (together with the slide on which it was baked) placed in a cooling muffle, the mouth of which should be closed to prevent the change of temperature from being too rapid, and causing the teeth to become brittle. When the piece is sufficiently cool to handle, a second application of body is made for the purpose of repairing any defects that may have occurred in the baking; this done, the piece is again introduced as before into the upper muffle, then in the lower, allowing the second bake to become a little harder than the first, but not so much as to appear glossy. It is then withdrawn, and cooled as described above.

"A flesh colored compound is then applied which is called the gum enamel. This is also made plastic with water, and a thin coating is put over the body, and closely packed and carved around the teeth with small instruments made for the purpose,—still taking care to keep the crowns of the teeth clean and well defined. Small camel's-hair brushes are used wet with water, to cause the gum enamel and also the body, to settle more closely around the necks of the teeth; other brushes are also used dry to remove all particles of body, gum or other substances from the crowns of the teeth.

"After the application of the gum enamel, the piece is again subjected to the heat of the furnace as described for baking the body, with this difference:—the heat should be a little greater than for either of the preceding bakes. It should be a strong, sharp heat, in order to produce a smooth glossy appearance which is required for the enamel. These different degrees of heat for the first, second and third bakings should be carefully observed for the purpose of getting an even temper in the piece, and thereby preventing it from crazing or cracking in cooling.

"The enamel being thoroughly fused, the piece is withdrawn from the heated muffle, and passed into another, outside of the furnace. This muffle should be made quite hot before the denture is placed in it, in order to prolong the cooling process; for if the piece is cooled too rapidly, it is rendered more fragile. It is well to let the case remain in the cooling muffle, with the mouth of it closed, several hours before exposing it to the air. By baking just at night, the piece will be in proper condition to finish up the next morning.

"The finishing process consists simply in smoothing and polishing the plate, and burnishing the rim. It is then ready to be adjusted to the mouth. In baking, great care is necessary to prevent the piece from becoming gassed. This can be avoided by allowing the gas to escape entirely from the burning coal or coke in the furnace before the piece is introduced

into the muffle. The presence of gas is indicated by the blue flame escaping from the coal. When the fire becomes clear, it is then safe to introduce the case to be baked (as before described) into the muffle. Pure anthracite coal is the best for this purpose, as it maintains a longer and stronger heat than coke. Bituminous coal is not good for this kind of work unless first converted into coke.

"It often occurs that the natural gums will change more or less after the teeth are inserted. In such cases a new impression should be taken from the mouth and a fusible die formed. The denture is then placed upon the die, and it will be seen at once where the change has taken place, then with the piece resting upon the die the artificial gum may be chipped off with a small hammer and chisel. The platinum plate being soft, can be refitted to the die very accurately with a burnisher, hammer and small driver made for the purpose. A new coat of body is then applied where the plate has been refitted, and then baked, cooled, enameled, and baked again,—still observing the same directions as detailed in the management of new pieces.

"If a tooth gets broken (a mishap which seldom occurs by use in the mouth), it can be replaced with another, by grinding out the remaining portion of the broken tooth, and the gum which covers the fang, and then fitting a new one in the place. This tooth need not be soldered to the inside rim; it is sufficient to grind a small notch or groove in the enamel which covers the lingual side of the rim for the pin of the tooth to fit into. The pin resting in the groove is covered with the body, at the same time it is applied around the base of the tooth, and when this body is baked, the tooth will become firmly fastened in place of the broken one. Any number of teeth that may be required can be replaced in this way. If it is desired to change the position of one or more teeth, or to make them longer, this can also be done as described above, with this additional precaution, which is simply to press softened wax upon the inside of the teeth and palatal arch of the denture before the others are

removed,—this wax will serve as a guide or index as to the relative change to be made, and also to sustain the teeth in place while they are being fitted as desired to the denture. The wax soon becomes hard and is readily removed as each successive tooth is ground and adjusted in its proper place.

"When the teeth are thus fitted with each pin accurately pressed into the groove prepared for it, and the wax being placed upon the inside to support the teeth in proper position,—body is filled in around the base of the new ones which are carved, trimmed and brushed, so as to have the crowns of the teeth clean and properly defined. The wax is then carefully removed from the piece, and more body is filled in around the teeth upon the inside,—filling up the grooves over the pins, and then carving, trimming, &c., as before, to give it the desired form. This done, if the teeth are set a little apart, and it is desired to keep them in that position, take a small piece of asbestos and gently press it in between the teeth at the cutting edges; this will prevent them from being drawn together when the body is being baked. The piece is now ready for the furnace, but it should not be baked hard enough to gloss the newly applied body; it should have more the appearance of Parian marble.

"This being done, it is then withdrawn from the furnace and transferred to a cooling muffle as before described. When sufficiently cool, the gum enamel is applied and baked with a sharp heat until it becomes smooth and glossy. To prevent the old gum from bleaching or becoming lighter colored in consequence of repeated bakings, a very thin coating of fresh gum enamel should be lightly brushed over the entire enameled surface of the piece. The enamel thus applied should be mixed with water, quite thin, so as to flow evenly over the surface, when applied with a camel's-hair brush. This should be done before the last baking, that the whole may be fused at the same time. Experience and judgment are essential requisites in order to produce good practical results. For example, if the carving of the body is not

properly done, the form and shading of the gum and roof will not appear natural when the work is finished; if the gum enamel is put on too thick it will produce a dark red color; if not thick enough it will be too light; if fused too hard it will be liable to craze or crack; if not hard enough, it will be rough or granular; if the piece becomes gassed in baking it will be porous and of a bluish color. Again the teeth of different persons vary as much as any features of the face, and present as great a variety of expressions. Therefore, in the construction of artificial dentures, the dentist should select and arrange the teeth with special reference to each individual case. The length, size, form, shade, and position of the teeth, should be varied to meet all the different physiognomical requirements that occur in dental practice.

"This system also combines with great advantage the restoration of the face in cases where the muscles have become sunken or fallen in from the loss of the teeth and consequent absorption of the alveolar processes. Here, again, the artistic skill of the dentist is brought into requisition. He should study the face of his patient as the artist studies his picture, for he displays his genius not upon canvas, but upon the living features of the face; and of how much more importance is the living picture, that reflects even the emotions of the heart, than the lifeless form upon canvas. He should know the origin and insertion of every muscle of which the face is formed, and what ones he is to raise, otherwise he will be liable to produce distortion instead of restoration. This improvement consists of prominences made upon the denture of such form and size as to bring out each muscle or sunken portion of the face to its original fullness; and when these are rightly formed they are not detected by the closest observer. There are four points of the face (of many persons) which the mere insertion of the teeth does not restore, viz., one upon each side beneath the malar or cheek

bone, and also a point upon each side of the base of the nose, in a line toward the front portion of the malar bone.

"The extent of this falling-in varies in different persons, according to their temperaments. If the lymphatic temperament predominates, the change will be slight. If nervous or sanguine, it may be very great. The muscles situated upon the sides of the face, and which rest upon the molar or back teeth, are the zygomaticus major, masseter, and buccinator. The loss of the above teeth cause these muscles to fall in. The principal muscles which form the front portion of the face and lips are the zygomaticus minor, levator labii superioris alaeque nasi, and orbicularis oris.

"These rest upon the front, eye, and bicuspid teeth, which, when lost, allow the muscles to sink in, thereby changing the form and expression of the mouth.

"The insertion of the front teeth will in a great measure bring out the lips, but there are two muscles in the front portion of the face which cannot, in many cases, be thus restored to their original position; one is the zygomaticus minor, which arises from the front part of the malar bone, and is inserted into the upper lip above the angle of the mouth; the other is the levator muscle, which arises from the nasal process and from the edge of the orbit above the infra orbitar foramen. It is inserted into the ala nasi or wing of the nose and upper lip.

"The prominences before mentioned, applied to these four points of the face, beneath the muscles just described, bring out that narrowness and sunken expression about the upper lip and cheeks to the same breadth and fullness which they formerly displayed. If skill and judgment have presided over all parts of the operation, the result will be highly pleasing, and of practical utility."*

* Inasmuch as the improvement for restoring the face has been claimed by others, the reader is referred for the evidences establishing the claim of Dr. Allen to priority of invention to the historical record which appears in the old American Journal of Dental Science of 1845. In the published proceedings of the American Society of Dental Surgeons of that year, it will be seen that a medal was awarded to one of its

Dr. Hunter's Formulas and Modes of Practice.—The following methods of compounding and applying the continuous gum materials, as practiced by Dr. W. M. Hunter, are reproduced from his latest published descriptions in 1852.

The following is a description of the materials and compounds employed:

"*Silex* should be of the finest and clearest description, and kept on hand ready ground, the finer the better.

"*Fused spar* should be the clearest felspar, such as is used by tooth manufacturers for enamels, completely fused in a porcelain furnace, and ground fine.

"*Calcined borax* is prepared by driving off the water of crystalization from the borax of commerce, by heating in a covered iron vessel over a slow fire, and it is better to use immediately after its preparation, as it attracts moisture. It should be perfectly clean and white, and free from lumps.

"*Caustic potassa optimus.*—Known also as potassa fusa.

"*Asbestos.*—Take the ordinary clean asbestos, free it from all fragments of talc or other foreign substances and grind fine, taking care to remove any hard fragments that may occur.

"*Granulated body.*—Take any hard tooth material (I use the following formula: spar 3 oz., silex 1½ oz., kaolin ½ oz.) and fuse completely. Any very hard porcelain, wedgewood ware or fine china, will answer the same purpose. Break and grind so that it will pass through a wire sieve No. 50, and again sift off the fine particles which will pass through No. 10 bolting cloth. It is then in grains about as fine as the finest gunpowder.

"*Flux.*—Upon this depends the whole of the future operations, and too much care cannot be taken in its preparation. It is composed of silex 8 oz., calcined borax 4 oz., caustic

members, inscribed, "Awarded to Dr. John Allen, for his invention for restoring the contour of the face, August, 1845." This, in connection with the fact that no other record upon this subject is found in our dental literature, fixes the date of this improvement.

potassa 1 oz. Grind the potassa fine in a wedgewood mortar, gradually add the other materials until they are thoroughly incorporated. Line a hessian crucible (as white as can be got) with pure kaolin, fill with the mass, and lute on a cover a piece of fire clay slab, with the same. Expose to a clear strong fire in a furnace with coke fuel for about half an hour, or until it is fused into a transparent glass, which should be clear and free from stain of any kind, more especially when it is used for gum enamels. Break this down and grind until fine enough to pass through a bolting cloth, when it will be ready for use.

"*Base.*—Take flux 1 oz., asbestos 2 oz., grind together very fine, completely intermixing. Add granulated body 1½ oz., and mix with a spatula to prevent grinding the granules of body any finer.

"*Gum enamels.*—No. 1. Flux 1 oz., fused spar 1 oz., English rose 40 grains. Grind the English rose extremely fine in a wedgewood mortar, and gradually add the flux and then the fused spar, grinding until the ingredients are thoroughly incorporated. Cut down a large hessian crucible so that it will slide into the muffle of a furnace, line with silex and kaolin each one part, put in the material and draw up the heat on it in a muffle to the point of *vitrifaction* not *fusion*, and withdraw from the muffle. The result will be a red cake of enamel which will easily leave the crucible, which after removing any adhering kaolin, is to be broken down and ground tolerably fine. It may now be tested and then (if of too strong a color) tempered by the addition of covering. This is the gum which flows at the lowest heat, and is never used when it is expected to solder.

"No. 2. Flux 1 oz., fused spar 2 oz., English rose 60 grains. Treat the same as No. 1. This a gum intermediate, and is used upon platina plates.

"No 3. Flux 1 oz., fused spar 3 oz., English rose 80 grains. Treat as the above. This gum is used in making pieces intended to be soldered on, either in full arches or in the

sections known as *block-work*. It is not necessary to grind very fine in preparing the above formulas for application.

"*Covering.*—What is termed covering, is the same as the formulas for gum, *minus* the English rose, and is made without any coloring whatever when it is used for tempering the above gums which are too highly colored, and which may be done by adding according to circumstances from 1 part of covering to 2 of gum, to 3 of covering to 1 of gum, thus procuring the desired shade. When it is to be used for covering the base prior to applying the gum, it may be colored with titanium, using from two to five grains to the ounce.

"*Investient.*—Take two measures of white quartz sand, mix with one measure of plaster of Paris, mixing with just enough water to make the mass plastic, and apply quickly. The slab on which the piece is set should be saturated with water to keep the material from setting too soon, and that it may unite with it.

"*Cement.*—Wax 1 oz., rosin 2 oz. The proportions of this will vary according to the weather; it should be strong enough to hold the teeth firmly, and yet brittle enough to chip away freely when cold. A little experience will enable any one to prepare it properly."

(Inasmuch as the method of constructing the platinum base, with Cleveland's modification of chamber, as described by Dr. H., has already been introduced, p. 274, this portion of the description is omitted in this connection.)

"After the plates are perfectly adapted to the mouth, place wax upon each, which trim to the proper outline as regards length and contour of countenance, marking the proper occlusion of the jaws and the median line. These waxen outlines are called the *drafts* and are carefully removed from the mouth, and an articulator taken by which to arrange the teeth.

"When the absorption is considerable and the plate in consequence is rather flat, it is necessary to solder a band or rim

along the line where the upper draft meets the plate, about one-sixteenth or one-eighth of an inch wide, and fitting up against the outline of the draft. When the ridge is still prominent, the block will not of course be brought out against the lip so much, and a wire may be soldered on instead of the wider band. I think one or the other necessary, as it gives a thick edge to the block, rendering it far less liable to crack off than if it were reduced to a sharp angle; it also allows the edge of the plate to be bent in against the gum, or away from it, as circumstances may require, and affords in many cases a far better support for the plates than can be given to one in which the band is *struck up* or the edge turned over with pliers, where the block must extend to the edge of the plate. Some few cases do occur when the band may be struck as far back as the bicuspids with advantage, and some in the lower jaw where it is necessary to solder on the band, but the general practice is not so.

"The upper teeth are first arranged on the plate antagonizing with the lower draft, supported by wax or cement, or both. Then remove the lower draft and arrange the lower teeth so that the coaptation of the cutting edges of the teeth shall be perfect as desired. The patient may now be called in again, and any change in the arrangement made to gratify his or her taste or whim. Now place the plates with the teeth thereon, on their respective casts, oil the cast below the plate and apply plaster of Paris over the edge and face of the teeth and down on the cast, say an inch below the edge of the plate. This will hold them firmly in their place while you remove the wax and cement from the inside, and fit and rivet backs to the teeth. When backed, cut the plaster through in two or more places, and remove. Clean the plate by heating. Cut the plaster so that while it will enable you to give each tooth its proper position, you can readily remove it from the teeth when they are cemented to the plate. Adjust the sections of plaster and the teeth in their proper positions. The plaster may be held by a piece of soft wire.

Cement the teeth to the plate and strengthen the cement by laying slips of wood half an inch long along the joint and against the teeth. (I generally use the matches which are so plenty about the laboratory.) Remove the sections of plaster, being careful not to displace any of the teeth. If it be intended to cover the strap with enamel, you should solder a wire after backing, and previous to replacing the teeth, along the plate parallel with the bottom of the straps, and about $\frac{1}{8}$ or $\frac{1}{4}$ of an inch from them.

"The teeth are now backed and cemented to the plate, and present an open space between the plate and the teeth, which is to be filled up with the base, using it quite wet to fill up the small interstices, filling in the rest as *hard and dry as possible.* Fill the cavity *between* the plates in the same manner, and oil the edge. Oil the surface of the base, envelop in the investient (precisely as you would put an ordinary job into plaster and sand for soldering) and set on a fire-clay slab previously saturated with water. When hard chip away the cement, cooling it if necessary with ice, until it is perfectly clean. Along the joints place scraps and filings of platina very freely, and cover all the surface you wish to enamel with coarse filings, holding them to their place by borax ground fine with water. Apply pure gold as a solder quite freely, say two dwt. or more to a single set. Put in a muffle and bring up a gradual heat until the gold flows *freely*, which heat is all that will be needed for the base; withdraw and cool in a muffle. Remove the investient and fill up all crevices and interstices not already filled, with covering No. 2; cover the straps and base with the same, about as thick as a dime, and cover this with gum No. 2 about half that thickness. At the same time enamel the base in the chamber, and cover with thick soft paper. Set the plate down on the investient on a slab, with the edges of the teeth up. Fuse in a muffle and the work is completed. Blemishes may occur in the gum from a want of skill in the manipulation; should such occur, remedy by applying gum No. 1.

"Should the patient object to the use of platina as a base, the work can be made as above on an alloy of gold and platina 20 carets fine, and soldered with pure gold, &c., as above. In all cases, however, where it is used, the upper plate should be made as I have described above, but with platina any kind of plate can be used.

"*Ordinary Alloy.*—Blocks may be made and soldered to the ordinary plate if the absorption is sufficient to require much gum, without any platina. Arrange the teeth on wax on the plate, fill out the desired outline of gum, and apply plaster one-fourth of an inch thick over the face of the teeth, wax and cast. When hard, cut it into sections, (cutting between the canines and bicuspids,) remove the wax from the plate and teeth, bind the sections of the plaster mold thus made to their places with a wire, oil its surface and that of the plate, fill in the space beneath the teeth with the base, wet at first, but towards the last as hard and dry as possible, and thoroughly compacted. Trim to the desired outline on the inside, oil the base, and fill the whole palatal space with investient, supporting the block on its lingual side. Remove the plaster mold, and cut through the block with a very thin blade between the canines and bicuspids. Take the whole job off of the plate, and set on a fire-clay slab with investient, the edges of the teeth down; bring up the heat in a muffle to the melting point of pure gold. When cold, cover and gum with No. 3 gum and covering.

"Another mode is to back the sections with a continuous strap, (using only the lower pin,) fill in the base from the front, use covering and gum No. 3, finish at one heat. When the blocks are placed upon the plate, the other pin is used to fasten the gold back, which is soldered to it and the platina half-back; neither of these backs need be very heavy, as soldering the two together gives great strength and stiffness. Very delicate block work can be made in this way, and it is applicable also, where a few teeth only are needed.

"A very pretty method, where a section of two or four

teeth (incisors) is needed, and only a thin flange of gum, is to fit gum teeth into the space, unite by the lower platina with the continuous back, and unite the joint with gum No. 3. A tooth left ungummed by the manufacturer would be best for the purpose. The same may be applied to blocks for a full arch, remembering not to depend entirely upon platina backs.

"The method I prefer for full arches on ordinary plate, is to take a ribbon of platina a little wider than the intended base, and of the length of the arch, cut it nearly through in five places, viz., between the front incisors, between the lateral incisors and canines, and between the bicuspids. Adapt it to the form of the alveolar ridge with a hammer and pliers, and swage on the plate along where the teeth are to be set. Solder up the joints with pure gold, and proceed to back the teeth, etc., as before; making preparations for fastening, and removing the slip of platina from the gold plate before enveloping in the investient, when proceed as before.

"When the teeth are arranged, insert four platina tubes about one line in diameter, two between the molars, and two between the cuspidati and bicuspids, and solder to the platina base. These are designed, after the teeth are finished, to be the means of fastening to the gold plate, either by riveting in the usual way, or by soldering pins to the gold plate passing up through the tubes, fastening with sulphur or wooden dowels. By these methods we are enabled to readily remove the block and repair it, should it meet with any accident, and also in case absorption should go on, to restrike the plate, or to lengthen the teeth. The rim should be put on the gold plate after the block is finished; it gives great additional strength and a beautiful finish.

"*Memoranda.*—In preparing material, always grind dry, and the most scrupulous cleanliness should attend all of the manipulations. In all cases where heat is applied to an article in this system, it should be raised gradually from the

bottom of the muffle and never run into a heat. Where it is desired to lengthen any of the teeth, either incisors or masticators, or to mend a broken tooth, it may be done with *covering*, properly colored with platina, cobalt or titanium.

"In preparing a piece of work, wash it with great care, using a stiff brush and pulverized pumice-stone. Bake over a slow fire to expel all moisture, and wash again, when it will be ready for any new application of the enamel. Absorption, occurring after a case has been some time worn, by allowing the jaws to close nearer, causes the lower jaw to come forward and drive the upper set out of the mouth. By putting the covering on the grinding surface of the back teeth in sufficient quantities to make up the desired length, the co-aptation of the denture will be restored, and with it the original usefulness.

"Any alloy containing copper or silver should not be used for solder or plate, if it is intended to fuse a gum over the lingual side of the teeth, as it will surely stain the gum. Simple platina backs alone do not possess the requisite stiffness, and should always be covered on platina with the enamel, and on gold with another gold back. In backing the teeth, lap the backs or neatly join them up as far as the lower pin in the tooth, and higher if admissible, and in soldering, be sure to have the joint so made *perfectly soldered.*"

Application of Continuous Gum to Partial Sets.—The following method of constructing partial sets of artificial teeth with continuous gum is taken from a practical and well-written paper on this process by Dr. W. B. Roberts.

"Partial cases may be made of continuous gum; but the work is so various in its nature, that the dentist must necessarily depend much upon his own judgment. Difficult cases will constantly present themselves, that will require the exercise of much study and ingenuity; in which the general instruction that can be given in words, may be of but little service. The first attempt of this kind in my own experi-

ence, was in replacing two central incisors. Taking two continuous gum teeth, I placed upon them a platinum lining, slitting this down along the edge of one tooth nearly through the piece and up the edge of the other tooth by a parallel cut, leaving the two parts joined together by a narrow slip. This allowed sufficient motion between the teeth, so that they could be adjusted as desired. I then placed a bit of tissue paper on the plaster model, covering the spot to be occupied by the teeth and gum, to prevent the adhesion of the body to the plaster, and holding the two incisors in their places, I worked the body into all the depressions of the gum and around the roots of the teeth. I then removed the whole from the model, and placed the piece in a paste of pulverized silex, or plaster and asbestos, upon a slide, and baked as described for full sets. The little slip of platinum kept the two teeth in place. The work shrunk somewhat; but this was remedied by again placing the piece upon the model, with the intervention of tissue paper covered with a thin coating of body. Into this I pressed the piece, till it occupied its true place, and then filled in again with more body all the crevices around the roots of the teeth, and rebaked.

"After enameling, if the work has been carefully and skillfully done upon this plan, it will be as fine a piece in appearance and fit, as can be made. It may then be soldered to a gold plate, and the little strip of platinum between the teeth be cut out. With the body and gum formerly in use many difficulties were often encountered from discoloration of the gum, or from other injuries incurred in soldering. But with Roberts' material, these are easily avoided, and the piece can be treated the same as a block or single gum teeth. In partial sets on entire plates of platinum, I have sometimes found trouble, from the enamel giving away upon the small narrow points that connect the teeth with the plate, by the shock occasioned in biting. I have consequently left these points uncovered, and used two or three thicknesses of platinum to give greater strength. But where this is likely to

occur, gold plates would be preferable, if nicely adapted with single gum teeth, or blocks of continuous gum, as the case might require. I have also applied continuous gum in cases where the natural teeth, from one to five in number, were left in the mouth, by making the plates as in full sets, cutting out around the natural ones, and raising a small bead, or placing a light wire around about one-eighth of an inch or more from the teeth, against which the gum or body is to be finished. The points around the teeth are to be left free, in order to be burnished down in case of imperfections caused by the difficulty of obtaining exact impressions in these places. In such cases, I have sometimes formed a strong standard of several thicknesses of platinum fitting closely against one or more natural teeth, leaving a loophole through which to run a gold clasp for afterward securing the artificial set.

"I have also secured the gold to the standard by rivets of platinum, and sometimes by two or three gold screws, not providing, in these cases, the loop-hole. These methods are to be preferred to using solder for fastening; for, in case of repair, the clasps are easily removed without leaving any foreign substance: but in case of soldering, however carefully they may be removed, there will remain some alloy, which in the baking heat to which the piece is to be exposed, will be incorporated with the platinum. Even so small an amount of silver as may be in gold coin used for solder will communicate a yellowish tinge to the gum, spoiling the whole work. Many operators in their early practice, I doubt not, experienced this result; and learned that no alloys, especially of silver or copper, can be admissible for soldering this work. I have tried platinum clasps without success, as no elasticity could be obtained, and therefore would not hold upon the teeth. Another source of mischief may properly be noticed in this place. In baking especially with a new furnace, or with muffles lately renewed, either at the first or second heat, or it may be in enameling, the piece is sometimes changed in its

texture and color, as is supposed by the gases present, and the phenomenon is called gassing the piece. The body becomes porous like honey-comb, and of a bluish color. When this occurs, there is no remedy but to place it upon the metallic die, remove the whole of the injured part, and replace it with a new coating of body and gum. The teeth are seldom, if ever, thus affected. As a precaution, the muffles should be well ventilated with holes for the passage of the heated air and gases.

CHAPTER XV.

VULCANITE BASE.

The method of mounting artificial teeth in a base of vulcanized or indurated India-rubber, is of comparatively recent origin, having been first practiced and introduced to the notice of the profession in 1853. Since that time, the preparation of the materials, and the methods of manipulating them, have undergone various and important modifications and improvements. The process is now very generally adopted by dental practitioners throughout the United States, and in parts of Europe, and the very general recognition of the fitness of vulcanized caoutchouc or India-rubber, for the various purposes to which it has been applied in the practice of dental prosthesis, would seem to challenge for it favorable comparison with other approved substances employed for similar purposes.

General Properties of India-Rubber.—Caoutchouc, gum-elastic, or India-rubber, exists as a milky juice in several plants, but is extracted chiefly from the *siphonia cahuca*, which grows in South America and Java. It is discharged through numerous incisions made in the tree through the bark, and is spread upon clay molds, and dried in the sun, or with the smoke of a fire which blackens it. The juice when first obtained is of a pale yellow color, of about the consistence of cream, and has a specific gravity of about 1·012. In the process of drying, 55 per cent. is lost, the residuary 45 being elastic gum. It immediately coagulates, by reason of its albumen, on the application of heat, the elastic gum rising to the surface. The specific gravity of the juice is diminished by inspissation, becoming 0·925 when

hard, and cannot be permanently increased by any degree of pressure. When once stiffened by cold, or continued quiescence, it cannot be restored to its original condition of juiciness.

The inspissated juice, or crude rubber of commerce, is altogether insoluble in water or alcohol, but is readily soluble in ether deprived of its alcohol by washing, affording a colorless solution. On evaporation of the ether, the gum resumes its original condition. It swells to thirty times its bulk when treated with hot naptha, and if triturated in this condition in a mortar, and pressed through a seive, furnishes a homogeneous varnish employed in the preparation of a water-proof cloth.

Caoutchouc is soluble in the fixed oils, but is not readily decomposed by cold sulphuric acid or diluted nitric acid, and is unaffected by either muriatic acid gas, sulphurous acid gas, fluo-silicic acid, ammonia or chlorine, nor is it dissolved by the strongest caustic potash lye, even at a boiling heat, and is therefore highly esteemed as an appliance of the chemical laboratory. According to the experiments of Ure, Faraday, and others, caoutchouc contains no oxygen, as almost all other solid vegetable products do, but is a mere compound of carbon and hydrogen in the proportion of three atoms of the former to two of the latter. From its property of resisting the corrosive action of acid vapors, and its tenacity of adhesion to glass, caoutchouc, when melted, forms a very excellent lute for chemical apparata.

Such are some of the properties of this remarkable product, the uses of which have been almost immeasurably extended since the first successful efforts to produce artificial induration by Charles Goodyear in 1844.

Compounding Rubber for Dental Purposes.—India-rubber is prepared for vulcanizing by incorporating with it, in varying proportions, either sulphur alone, or some of its compounds, sulphur being an essential component of all vulcanizable gum compounds. For dental purposes, the coloring is effected in most preparations by the introduction of vermillion

(sulphuret of mercury). These substances, properly combined, are subjected to artificial heat for a specified time, producing a hard, elastic, horn-like substance, possessing in a large degree (with the exception of the requisite gum color) all the essential properties of a base or support for artificial teeth, as lightness, strength, durability, imperviousness to fluids, insolubility in the oral secretions, unchangeableness in exposure to ordinary temperatures, etc.

In view of the extended and increasing applicability of vulcanized rubber to the necessities of the dental practitioner, and the restrictions sought to be imposed upon its legitimate uses in dentistry by the unjust exactions of a rapacious monopoly, it is thought that whatever will lead, by inciting to more extended experiments, to the discovery of unknown or improved modes of compounding rubber for the purposes specified, will not be deemed foreign to the objects contemplated in a work like the present. In this belief, we introduce, without abridgment, the following somewhat elaborate and carefully-conducted series of experiments in compounding mixtures for hard rubber, of diverse appearances and properties, conducted by Professor E. Wildman, and described in a valuable monograph of recent date, entitled "Instructions in Vulcanite."

"Caoutchouc may be mixed with sulphur, and the coloring matter, by being passed repeatedly between steam-heated rollers; or, the caoutchouc may be first reduced to a pulpy or gelatinous state by some one of its solvents, and the sulphur and coloring matter then mixed with it; in either case the sulphur and coloring should be ground extremely fine, and then the whole ingredients thoroughly incorporated together to insure a satisfactory result.

"For experimental purposes the latter method of mixing can be readily practiced by any one. Of the solvents, ether deprived of its alcohol, chloroform and bisulphide of carbon are objectionable on account of their expense, and also the operator being compelled to inhale their vapor during the

manipulation. Coal naptha, or benzine, are preferable on this account; they readily reduce the caoutchouc to the proper consistency; but after having been mixed, and the solvent evaporated, the rubber is non-adhesive, and does not pack well. Oil of turpentine leaves the rubber somewhat adhesive, and in a good condition to pack. Therefore, I have found it a better plan to soften the caoutchouc in oil of turpentine, or, in equal parts of coal naptha, or benzine, and oil of turpentine.

"In reducing caoutchouc to a gelatinous condition, it requires a large quantity of the solvent in proportion to the gum. This is remedied by introducing into the solvent from five to fifty per cent. of alcohol; in this case the caoutchouc becomes gelatinous, but does diffuse itself through the solvent, thereby leaving much of it after the softened caoutchouc is removed, for future use.

"I generally levigate the coloring matter and sulphur in spirits of turpentine, first reducing the coloring matter very fine, then adding the sulphur, and also reducing it very fine, then add a little of the pulpy caoutchouc, mix thoroughly, and proceed in this manner until the whole is incorporated into a perfectly homogenous mass. When the coloring matter is ground in linseed oil, the caoutchouc may be softened in naptha, or benzine, and it will pack well, as the oil renders it adhesive; but I am inclined to believe that oil, even in a small quantity, injures the hardness and polish of the rubber.

"After the materials are well mixed, the mass should be spread on a glass plate with a spatula, and allowed to remain until the solvent has been evaporated.

"The apparatus used in making the following mixtures were a muller and glass plate to grind the colors and sulphur, a spatula, broad-mouth bottles, in which to gelatinize the caoutchouc, and window glass, upon which to spread it when mixed. The caoutchouc was the best Para, and the time and temperature in vulcanizing was the same as that for the American Hard Rubber Company's red rubber.

"*To test the Combination of Caoutchouc and Sulphur alone:*

A.	Caoutchouc	48
	Sulphur	24

This gave a dark brown rubber, varying shade in different mixtures; it was strong, compact, and tough, and received a fine polish. This color may be toned down to a dark oak by bleaching in alcohol.

"**B.** This experiment was performed with caoutchouc which had not been smoked; this gum was translucent and nearly colorless, having merely a light straw tint. The proportions were the same as for A.

"*Result.*—Color and properties the same as the above, showing that the natural color of hard rubber composed of simply caoutchouc and sulphur is a dark brown.

"*To test the Coloring Properties of Red Oxide of Iron.*—The following formula gave the best results of the many tried:

C.	Caoutchouc	48
	Sulphur	24
	Red oxide of iron, (rouge)	36

"*Result.*—Texture good; color in different mixtures varied from almost black to black red; the color was more on the red when the rouge was ground in oil than when in spirits of turpentine; after exposure in alcohol to the rays of the sun, the red was better developed, but even then it was much darker than the Company's red rubber. The sulphur decomposed the oxide of iron, forming a dark sulphide, thereby destroying its coloring effect.

"*Vermillion for producing a Red.*—Numerous experiments were tried to ascertain the quantity of vermillion necessary to overcome the natural brown and produce a red color; the following mixture may be set down as the lowest:

D.	Caoutchouc	48
	Sulphur	24
	Vermillion	36

"Some mixtures made according to this formula were darker and some lighter, owing to the different varieties of vermillion used. The shade was made much lighter by bleaching in alcohol. To bring it to a bright red when vulcanized would require much more vermillion, perhaps equal proportions of caoutchouc and vermillion. This formula produced a good, strong, compact rubber. If not identical in composition with the Company's red, it so closely resembles it in texture, strength, and appearance, and in every particular, it must very nearly approximate thereto.

"*To produce a Yellow.*—The coloring effect of chrome yellow was tested; it gave a slate color, the chromate of lead being decomposed, setting free the chromic acid, and forming a sulphide of lead, stone ochre, and Naples yellow and the common orpiment of commerce, were tried with no better results. Pure orpiment or king's yellow gave, when bleached a lemon yellow, when mixed as follows:

E.	Caoutchouc	48
	Sulphur	24
	King's yellow	36

"Although the color produced by this substance was much more satisfactory than any of the preceding, its use is objectionable, because the texture of the rubber was not good, and the king's yellow being sulphide of arsenic is very poisonous.

"The following formula gives a good reliable yellow, viz.:

F.	Caoutchouc	48
	Sulphur	24
	Sulphide of cadmium	36

"This requires bleaching to develop the color fully; it is then much better than that produced by orpiment, is more on the orange, the texture of the rubber is good, and its use is not objectionable.

"*For a Lighter Yellow*—

G.	Caoutchouc	48
	Sulphur	36
	Sulph. cd.	36
	White ox. zinc	12

"The white oxide of zinc toned down the deep yellow to more of a lemon color, similar to that produced by the orpiment, at the same time the rubber was of good texture.

"Experiments to produce a pink and a flesh-color, so far have not been successful in producing the desired results, yet some of them are worthy of note.

H.	Caoutchouc	48
	Sulphur	24
	White ox. zinc	30
	Vermillion	10

"When bleached, gave a dark pink, the color not so good as the English; texture close; not so strong as the brown or red.

"*Variation of the above.*

I.	Caoutchouc	48
	Sulphur	24
	White ox. zinc	36
	Vermillion	10

"Vulcanized brown, after bleaching, it was a shade lighter than the preceding.

"The mixture of

K.	Caoutchouc	48
	Sulphur	24
	White ox. zinc	48
	E. vermillion	10
	Sulphide of cadmium	6

after bleaching, produced a buff.

"*Variation of above.*—

L.	Caoutchouc	48
	Sulphur	24
	White ox. zinc	96
	Vermillion	5
	Sulphide of cadmium	3

This produced a lighter shade—a light buff.

"To ascertain the effect of white oxide of zinc upon the natural brown of vulcanized rubber, numerous mixtures were made. The best Lehigh white oxide was used.

N.	Caoutchouc	48
	Sulphur	24
	White ox zinc	36

This produced a drab after bleaching—texture good.

O.	Caoutchouc	48
	Sulphur	24
	White oxide of zinc	48

"When bleached gave a light drab of good texture, and in appearance approximates very near to that of the American Hard Rubber Company's white.

P.	Caoutchouc	48
	Sulphur	24
	White oxide of zinc	96

"This after bleaching gave a grayish white. These three preceding mixtures were repeated by varying the proportion of sulphur, substituting thirty-six for twenty-four, the object of this was to give the rubber additional hardness; this change of proportions had the desired effect, but at the same time the color was impaired. All of these mixtures vulcanize a brownish color, and require to be bleached by the rays of the sun in alcohol for their development.

"*To produce a Black* Rubber.

T.	Caoutchouc	48
	Sulphur	24
	Ivory black, or drop black	24

"This mixture gave a good black.

U.	Caoutchouc	48
	Sulphur	24
	Ivory, or drop black	48

"This produced an excellent *jet black*, the rubber was hard and of good texture.

"The drop black which is in lumps containing gum I have uniformly found to produce a porous rubber, whilst the article under the same name found in commerce, free from gum, gave good results.

"By taking several of these different mixtures, (such as the taste of the operator may dictate) and cutting them into shreds, then incorporating them together, and again cutting the mass into small pieces suitable for packing, a very pretty mottled rubber may be made, suitable for hurdles, &c.

"After being vulcanized and polished, it must be bleached in alcohol to fully develop the colors, although some of the mixtures present a pleasing appearance without the bleaching process.

"In finishing mottled rubber, owing to the several colored mixtures having a different degree of hardness, after the file, prepare for the polishing process by obliterating the file marks with a flat piece of Scotch stone.

"The introduction of shellac was tried in one experiment, viz.:

Caoutchouc	48
Sulphur	24
Vermillion	40
Shellac	12

"The addition of shellac did appear to improve the compound in appearance or texture.

"I have now presented the most interesting of the successful results of my experiments in compounding mixtures for making hard rubber, and would now call the attention of those who desire to pursue this subject experimentally, that to color rubber, three points are essential: First, the color must remain unchanged at the heat required for vulcanization. Second, it must withstand the action of sulphur at this temperature; and third, sufficient quantity must be added to the mixture to overpower the natural brown of vulcanized rubber, before its shade can be developed. This fact shows us that all highly colored rubbers, or where the brown

is widely departed from, must be weakened by their being loaded with so much color or foreign matter; in proof of this, I have found no other mixture possessing strength and toughness equal to that made of simply caoutchouc and sulphur.

"The following table gives, very nearly the percentage of caoutchouc contained in several of the preceding formula. Also that of Ash & Sons' Pink No. 1, their S. P., their white, and the white made by the American Hard Rubber Company. The percentage given of these latter is based upon calculation.

"From the results of the preceding experiments, it is evident we may substitute Ash & Sons' black and the American Hard Rubber Company's brown for the A, brown in the table. Also the English deep red and the American Hard Rubber Company's red for D, the red in the table.

	Caoutchouc.	Sulphur.	Vermillion.			Parts in.
A. Brown	$66\frac{2}{3}$	$33\frac{1}{3}$				100
D. Red	44	22	33			99
					Sulp. Cad.	
F. Yellow	44	22			33	99
					Ox. Zn.	
H. Pink	$43\frac{2}{3}$	$21\frac{1}{3}$	9		27	100
				Sulp. Cad.		
K. Buff	35·4	17·2+	7 3	4·4	35 4	100
N. Drab	44	22			33	99
O. Lighter Drab	40	20			40	
P. Grayish White	28 5	14·3			57 1+	100
					Black.	
T. Black	50	25			25	100
U. Jet	40	20			40	100
					White earthy matter.	
Ash & Son's Pink, No. 1	24	12	18		48	102
					Ox. Zn.	
" " S. P.	35 6	17 8	26·6		20	100
" " White	$32\frac{2}{3}$	$16\frac{1}{3}$			51	100
Am. H. R. Co's White	$32\frac{2}{3}$	$16\frac{1}{3}$			51	100

"The calculation for the component parts of Ash & Sons' Pink Rubber is based upon the method given in the patent

for making pink rubber for dental uses, the quantity of fixed matter it is found to contain, and taking formula D as the composition of red rubber. It will be found, upon examination of this data, that if there is any error in the quantity of caoutchouc given to the pink, it is in its favor. A glance at the table will at once show its and other light rubbers' inferiority to either brown or red for dental purposes.

"The calculation of the percentage of Ash & Sons' S. P. is based upon the quantity of fixed matter found in it, and that fixed matter having been mixed a red rubber compounded as in formula D. This is evidently superior to the pink, but inferior to either the red or brown.

"Caoutchouc being the *cement* which binds the whole together, if any compound should contain but a small proportion of it, and if any substance prejudicial to the system should enter into its composition, (and in the patent referred to for making pink rubber, such substances are recommended,) its weakness of texture from the want of sufficient adhesion of its particles would render it liable to produce injurious effects by its susceptibility to abrasion in the mouth."

Some very interesting experiments were also made by Prof. Wildman to ascertain, by the application of heat, the amount of fixed matter contained in various specimens of rubber compounds. A condensed statement of the results obtained is exhibited in the following table:

	Per Cent. of Fixed Matter.	
1. Specimens of Deep Pink,	60	
2. English Pink,	48	White Clay.
3. Ash & Sons' Pale Pink, No. 1,	48	" "
4. " " Deep Pink, No. 1, X,	47	Oxide of Zinc.
5. " " S. P.,	20	" "
6. " " Black,	4	Dark Ash.
7. " " White,	51	White Ox. Zic.
8 English Red,	6	Dark Ash.
9. Dieffenbach's Red,	16	" "
10. American Hard Rubber Company's Red,	5	" "
11. " " " " White,	51	White Ox. Zic.
12. " " " " Brown, near,	4	Dark Ash.
13. My own Brown, (C. 2, S. 1), Near,	3	" "
14. " " Red, (C. 48, S. 24, V. 36),	2	" "

The author observes: "These experiments show us that pink and light rubbers for dental purposes are heavily loaded with such foreign matter as white clay and oxide of zinc, and some to the extent of fifty-one per cent. of their weight. Ash & Sons' S. P. is decidedly the best of his light rubbers, containing only twenty per cent. of fixed matter.

"Again, Ash & Sons' black (brown), the American Hard Rubber Company's brown, and my own brown, give results, respectively four, near four, and near three per cent. of fixed matter. My own I know was made of pure caoutchouc and of sulphur; hence from the residues of the two former so nearly approximating thereto, and also from their similarity of texture and appearance after being vulcanized, we must arrive at the conclusion they are of the same composition, and are therefore good and reliable brown rubbers.

"When we examine the results of the experiments upon the English deep red, that made by the American Hard Rubber Company, and my own red, we find the fixed matter to be six, five, and two per cent. respectively. My own red was made of pure Para caoutchouc, vermillion and sulphur. The small disparity of fixed matter found in these rubbers may have arisen from the different state of purity of the caoutchouc used in compounding them.

"It is evident that the specimens of English red and of the American Hard Rubber Company's red, were not loaded with earthy matter or oxides of zinc or lead, for if they were, the clay would have given us a greater percentage of fixed matter. Oxide of zinc is fixed in the fire at a white heat, and if present would have produced a similar result. Oxide of lead would have shown itself by its reduction, and the greater weight of residue.

"The conclusion we would naturally arrive at from the results of these experiments is, that the American Hard Rubber Company's red, and the English deep red, are the best red rubbers offered for dental purposes."

Objections to the Use of Rubber Considered.—It may not

be inappropriate, in this connection, to advert briefly to some of the objections which have been urged against the vulcanized rubber as applied to dental purposes. Prominent among these is, that dental substitutes constructed of rubber combining so large a proportion of sulphuret of mercury are, under favoring circumstances, liable to produce mercurial ptyalism. That the constitutional action of mercury consequent on the wearing of vulcanite plates, has been detected in some instances, is affirmed by many in the profession whose testimony is entitled to consideration. On the other hand it is claimed by the great mass of practitioners who have made extended use of this material, and who may be deemed competent to recognize the constitutional and local action of mercurials where it exists, that no such effects are clearly traceable to this source. One conclusively proven case of ptyalism, it must be observed however, clearly referable to the presence of a vulcanite plate in the mouth, must be accepted as invalidating and discrediting all negative evidences however well supported by careful or extended observations. When the latter, however, are considered in connection with carefully conducted experiments which have uniformly failed to detect the presence of free mercury in dental vulcanite, and also with certain well-grounded facts, and inferences affirming the inertness of vermillion in a state of combination with rubber and sulphur, it may be reasonably conjectured that the reported cases of ptyalism have been inadvertently confounded with other conditions of the oral cavity assimilating mercurial salivation, or, that ptyalism, if actually existing, arose from other and unsuspected causes.

Prof. E. Wildman relates the following experiment:

"To ascertain if there was any free mercury in the American Hard Rubber Company's red rubber as has been asserted, or any evolved by the decomposition of the sulphuret during vulcanization, a bulb was blown at the end of a glass tube; into this, red rubber was inserted, the tube was then bent above the bulb in the form of retort, and the open

end drawn out upwards to a capillary point. The bulb containing the rubber was placed in a bath of paraffin and vulcanized for one hour and a quarter at 320° F.; during which time the opposite end was kept cold, to condense the mercury should any come over. The result of this, and several similar experiments was, no trace of mercury could be detected, free sulphur was sublimed and condensed in a small quantity in the cold parts of the tube."

In discussing this subject in the last edition of Harris' "Dental Surgery," Prof. P. H. Austen, dissenting from the opinion that vulcanized rubber can exert any appreciable medicinal action in the mouth, observes:

"Pure sulphuret of Mercury is reckoned by Orfila as medicinally inert. Fumigation, by *vaporizing* the mercury, gives it a medicinal activity; but this requires a temperature of 600° F. Therefore, for the development of constitutional symptoms, we must have the presence of arsenic or of red-lead as impurities of the sulphuret; or the existence of free murcury.

"First, as to the impurities of arsenic or red-lead; they are not found in pure vermillion. But even if present such poisonous impurity would be rendered harmless, because completely invested by an insoluble coating of India-rubber. A piece of vulcanite is impervious to the fluids of the mouth; hence no part of its substance can be dissolved, and thus taken into the stomach. Any supposed medicinal action must, therefore, come from such minute particles as may be possibly worn off the lingual surface near the teeth where bread-crusts or other hard particles of food impinge. We have thus an almost infinitesimally small quantity of vulcanite taken into the stomach, one-third of which is inert vermillion, adulterated (we will suppose) with three per cent. of arsenic, and this coated with a layer of rubber, which, as previously stated, is insoluble in water, alcohol, alkalies, or weak acids. This very minute trace of arsenic, even if divested of its envelope of rubber, would have a purely homœopathic (and,

by consequence, not poisonous) action; whilst, if encased in rubber, which pervades every part of the material, it is absolutely inert. The same may be said of the less poisonous adulteration, red-lead.

"Secondly, as to the mercury, the researches of my colleagues, Prof. Johnston, with the microscope, and Prof. Mayer, by chemical analysis, have failed to discover the slightest trace in samples of the rubber used by me during several years. I have failed by any mechanical force to press out any globules, nor have I ever, in all my manipulations, seen the slightest particle of this metal, or been able with the microscope to detect it upon the surface of any finished piece. The one point, therefore, which I would suggest as calling for an extended series of thorough experiments and analyses is the presence of free mercury in the vulcanized material, for this I regard as the only agent that can possibly exert any deleterious action upon the system. That its presence is rare, I consider proven, but that it is *never* found, can only be, with any propriety, asserted or denied after the extended observations recommended, the observers being able to distinguish the minute crystals of sulphur from globules of mercury."

The employment of indurated rubber as a base for artificial teeth has also been objected to on the ground that, in consequence of its low conducting powers, it imparts a disagreeable sense of heat to the parts in the mouth in contact with it, inducing sponginess of the gums and a scalded appearance of the mucous membrane. Such occasional appearances are doubtless familiar to all who have had extended experience in the use of this material, but the cases in which they occur may be regarded as exceptional. The effects spoken of rarely subject the wearer to serious inconvenience, and will be found, in most instances, to be so slight as not to attract the patient's attention. They doubtless arise in many cases from a want of proper and habitual cleanliness of the substitute and mouth, and from other causes, independent of the nature of

the material itself. Other minor objections have been urged to the use of vulcanite, but they become unimportant when considered in connection with its generally recognized utility, and its almost unlimited adaptability to the exigencies of mechanical practice.

Method of Constructing an Entire Denture in a Base of Rubber.—As the manipulations concerned in the construction of a full upper set differ in no essential respect from those required in the formation of a denture for the inferior arch, except as the two differ in conformation, requiring corresponding modifications of practice which will readily suggest themselves, it will be sufficient to describe the method of constructing an entire denture for the upper jaw.

An impression of the mouth is first secured in the usual manner, and, for full sets, plaster of Paris is preferable to any other material for the purpose. In all practicable cases the same substance may be employed in cases of partial pieces. As rubber, when rendered plastic by heat and subjected to pressure, receives a distinct and perfect impress of the face of the model, it is important that the latter should be as smooth upon its surface, and as free from faultiness of form or surface blemish as possible. From the impression a plaster model is obtained, and if an air-chamber is required, it may be secured either by cutting out from the impression before filling in with plaster for the model, or it may be raised upon the model after the latter has been separated from the impression. For the latter purpose, lead is often used, but sheet tin, cut to the required form, is preferable, as the former leaves a tenacious coating of oxide adhering to the plate.

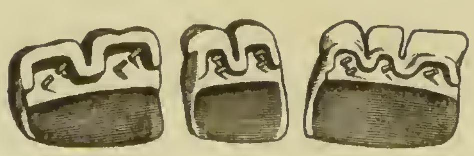
A temporary or model base plate is next conformed as accurately as possible to the face of the model, and for this purpose the *prepared gutta-percha* is the best, though sheet wax may be used. The former may be softened either by subjecting it to a dry heat until sufficiently plastic, or by immersing it in hot water. The face of the model being previously well saturated with cold water, to prevent the wax or gutta-percha from adhering, the latter is pressed or molded

accurately to the model with the fingers moistened with cold water, heating such portions from time to time as do not readily yield to pressure until an accurate adaptation of all portions of the plate is secured; then trim to the required dimensions.

Having fitted the temporary plate to the model, it is placed in the mouth with a wax guide or rim attached, when the latter is trimmed to the required width, fullness, and contour, and the "bite" of the under teeth secured; it is then removed and placed in its proper position on the model, and the heel of the latter extended an inch or more posteriorly to form an articulating surface for the remaining section of the antagonizing model, the latter being obtained in the manner described in connection with metallic plate base. The mode of procedure in cases of entire dentures for the upper and lower jaws differs in no respect from that practiced when gold or other metallic plate is used as a base.

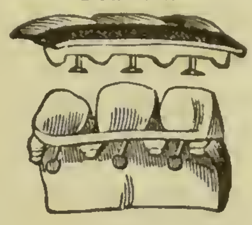
Arranging the Teeth.—Having secured an antagonizing model, the teeth are selected and arranged upon the temporary gutta-percha plate in the usual manner. The porcelain teeth used in this process are more commonly in the form of blocks or sections, although either single gum or plate teeth may be employed. Preference is given to the former, because fewer number of seams or joints are presented for the intrusion of rubber, which, though forming ever so minute a line of separation, mars the beauty of the finished work by an unsightly contrast in color with the porcelain gum, and which it is not always possible entirely to exclude. The increased strength of attachment formed by the greater number of pins also renders them more permanent and enduring than single teeth. Teeth made expressly for rubber base were originally manufactured with plain platina pins, longer and heavier than those used in connection with metallic plates (Fig. 91);

Fig. 91.



these, when used, were curved and pressed together, forming loops or hooks to prevent them withdrawing from the rubber. Subsequently, however, the detachment of the teeth was more securely and certainly provided against by the substitution of headed pins (Fig. 92), which rendered their withdrawal from the rubber impossible. For this valuable improvement the profession is indebted to Dr. S. S. White, whose genius, enterprise, and intelligence have been so long and unceasingly tributary to the needs of the dental practitioner.

FIG. 92.



In arranging the teeth, portions of the wax rim are cut away to form a bed for each tooth or block, as the case may be, grinding from the base of the latter and from their proximate edges until the proper position is assigned to the teeth, and the required antagonism is secured. The teeth, whether single or in the form of blocks, should be united to each other laterally with the greatest possible accuracy to prevent, as far as practicable, the intrusion of the gum material between them. To further provide against this, various expedients have been resorted to with the view of cementing or packing the joints in order to render them impervious to the rubber. The substances usually recommended for this purpose are, plaster or finely pulverized silex or felspar moistened with dilute liquid silex; os-artificial; soluble glass; gold or tin foil, or fusible metal packed into the joints, etc. Of the more destructible substances mentioned, Prof. Wildman very justly observes:* "All of these, in course of time, will yield to the action of the fluids of the mouth; and then the ill-fitted joints will be receptacles for soft particles of food, which will be more objectionable than having them filled with good solid rubber. The best filling is an accurately fitted joint; when so made, if the enveloping plaster is of good quality and properly mixed, and no undue force is used in bringing the section of the flask together,

* Instructions in Vulcanite, p. 19.

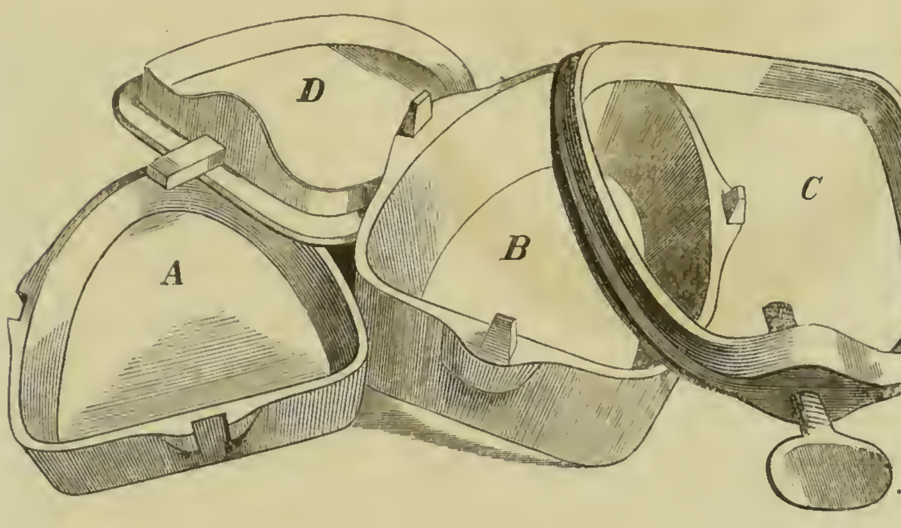
there is little danger of the rubber insinuating itself into the joints." As properly remarked, there is no expedient which will so certainly and effectually exclude the rubber as *close fitting joints,* and if the precaution is taken to secure an accurate and uniform coaptation of the ground surfaces where they unite in front, and the "enveloping plaster is of good quality and properly mixed, and no undue force is used in bringing the sections of the flask together," there will, at most, be but a very thin film of rubber, nearly imperceptible in the finished work, and wholly so in the mouth. To better effect the object stated, the author has been accustomed, when uniting porcelain blocks, to use a small magnifying glass, which reveals inaccuracies of coaptation not apparent to the naked eye.

The teeth having thus been properly united and arranged, the wax rim supporting them on the lingual side should be cut away and carved with heated instruments, especially designed for that purpose, until the required form and fullness are obtained, adding wax, if necessary, to the palatal portion of the plate, making it just enough thicker than that required in the completed set to compensate for waste in the process of final finishing. Any considerable excess of material should be avoided, since it will not only materially increase the labor of dressing the vulcanized plate, but tend to induce sponginess of the rubber under heat. A rim of wax should also be extended around the front and lateral borders of the plate, overlapping, somewhat, the extremities of the gum portions of the teeth. Wax used for the purposes indicated should be of the cleanest and purest varieties. A model set prepared in the manner described will present the appearance represented in Fig. 94.

Formation of the Mold or Matrix.—The process having been conducted thus far,—any defects in the arrangement of the teeth having been previously corrected upon trial of the plate in the mouth,—the next step in the operation is the formation of a mold or matrix in which the gum material is

packed and pressed preparatory to being indurated or vulcanized. In forming the matrix, a vulcanizing flask is used, the various parts of which are separately represented in Fig. 93. The lower section of the flask A, is first filled one-half or two-

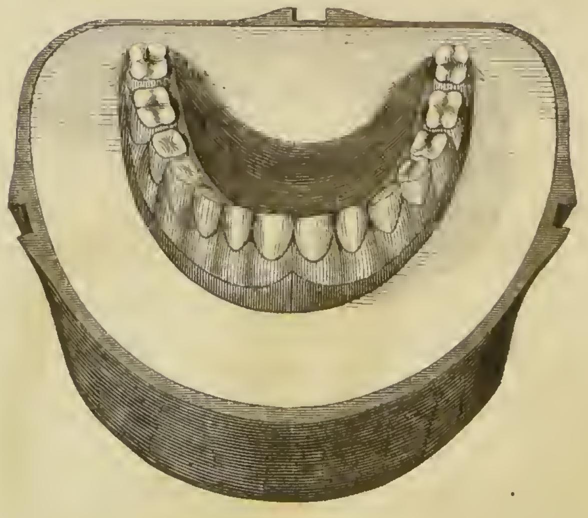
Fig. 93



thirds full of plaster mixed with water to the consistence of cream. Into this the base of the model, previously moistened with water (the plate and teeth being attached to the model), is immersed and additional portions of the plaster added, if necessary, filling the cup even with the upper edge, and extending it up the sides of the model to the lower edge of the external rim of wax attached to the borders of the gum plate. The base of the model should be cut away so that when placed in the flask the lower edge of the gum plate will extend but little above the level of the upper borders of the cup. The surface of the plaster is then trimmed smoothly, and coated with varnish and then oiled; all the exposed portions of the gum plate and wax are also oiled, leaving the surfaces of the teeth untouched. The several parts will now present the appearance represented in Fig. 94. The upper section of the flask B, is next placed in its proper position over the lower,—the slides formed in one, and corresponding

grooves in the other, determining an accurate relation of the two pieces. Into the upper rim of the flask, plaster, mixed to the consistence before mentioned, is now poured, filling it completely. The lid or cap D, also filled in with plaster, is then applied to the opening above, and the several parts of the flask compressed by placing them within the clamp C, and forcing them together with the screw, impacting the plaster and driving out the excess through the joints of the flask. As soon as condensation of the plaster takes place, the flask should be placed in a hot air-chamber or on a stove, and heated throughout sufficiently to soften, but not melt, the wax. The clamp is then removed and the two sections of the flask carefully separated by forcing a small chisel-shaped instrument in at different points between them, the lid closing the opening above remaining in place. On separating the flask, the teeth, with the wax and temporary plate, will be found attached to the section of the matrix last formed, the portions of the crowns of the teeth not covered with wax being imbedded in the plaster and their plate extremities presenting toward the matrix, as seen in Fig. 95. The gutta-percha plate and wax should now be carefully detached with such instruments as will best enable the operator to work out confined portions around the platinum pins and from the interstices between the teeth, being careful at the same time not to deface the plaster surface of the mold. To relieve the matrix more perfectly of all traces of wax not accessible to instruments, the section containing the teeth may

FIG. 94.

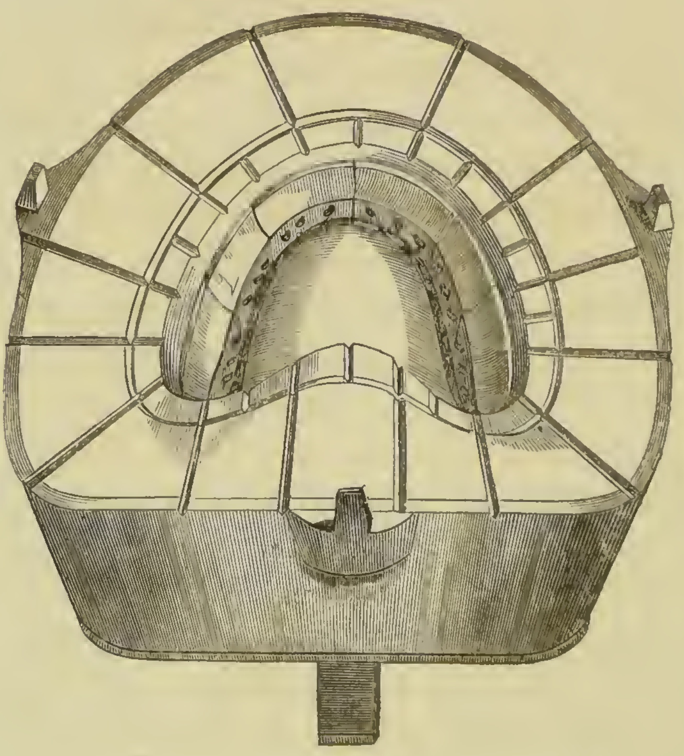


be subjected to a heat sufficient to induce its complete absorption by the plaster. The flask should be heated gradually, otherwise the contents may be suddenly and forcibly ejected in consequence of the too rapid evolution of vapor.

Before packing the material, provision should be made for the escape of any excess when the matrix is filled and the two sections of the flask are forced together, permitting the latter to close upon each other in exactly the same manner as before the introduction of the gum. If the vulcanizable substance becomes engaged between the surfaces of the plaster around the matrix, the vulcanized base will be increased in thickness just in proportion to that of the interposed layer of gum, and hence the teeth of replacement will be relatively elongated. This increased thickness of the base and consequent changed relation of the teeth to the maxillary ridge and to those of the opposing jaw, if but slight, may be immaterial in the application of full sets of teeth, but it is far different in the construction of partial pieces, where the perfection of the finished work depends in so great a degree upon a faultless preservation of the exact position originally assigned to the organs of replacement in the separate vacuities on the ridge. If, for example, in replacing the superior incisors, the approximation of the two sections forming the mold is obstructed by the intrusion of the gum material between the plaster surfaces, the teeth, whether plate or gum, will be relatively elongated in proportion to the increased thickness imparted to the base consequent upon the incomplete closure of the flask, and however accurately or skillfully the porcelain teeth may have been originally fitted to the vacuity in front, the artificial will be found to depart from the natural gum, while the porcelain crowns will be displaced and projected below those of the contiguous natural organs. Such displacement, in the cases last referred to, however small in degree, cannot fail either to impair or destroy the value, both as respects appearance and utility, of the substitute. The usual method of furnishing an exit to redundant material

is to form a series of conduits or grooves in the surface of the plaster containing the teeth, extending them from the edge of the matrix to the rim of the cup. The escape of the gum will be facilitated by filing notches at intervals around the rim of the flask, making the grooves in the plaster continuous with them, the grooves being an eighth or a fourth of an inch apart. To still more effectually prevent the intrusion of the vulcanite material between the surfaces of the opposing sections of plaster, a circular groove may be cut in the plaster within a line or two of the margins of the matrix, into which

Fig. 95.



narrow channels at short distances are made leading from the mold: others, again, are made at wider intervals from the circular groove to the outer margins of the flask, terminating as before in small notches formed in the rim of the cup. Fig. 95 exhibits the section of the flask containing the teeth with the channels formed as described; the remaining section con-

taining the model is shown in Fig. 96; the two pieces when closed upon each other forming the matrix. Into the grooved section of the mold, the vulcanizable substance is packed previous to being indurated. It is at this stage that the mate-

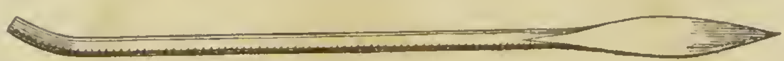
FIG. 96.

rials employed to exclude the rubber from between the teeth, and noticed in another place, are packed into the joints before the gum material is introduced. The face of the model should also be coated with some substance which will prevent the rubber from penetrating the pores of the plaster, and its adhesion to the surface of the model. Barker's ethereal solution, or the collodion of the shops, may be used for the purpose. Preference is given by Prof. Wildman to soluble glass or liquid silex as being more readily detached from the surface in finishing than the preparations mentioned. The latter should be allowed to dry perfectly before packing. Either of these substances is best applied with a small brush, coating the face of the model uniformly.

Packing the Mold.—The portion of the flask containing the teeth should be first heated in an oven or furnace, or over the flame of a spirit lamp, until the temperature of the whole is sufficient to render the vulcanizable gum soft and

pliable as successive portions are applied and pressed into the mold, and to retain it in that condition until the operation of packing is completed. Narrow strips of the gum material should first be worked carefully into the contracted groove underneath the platinum pins with small curved or straight-pointed spear-shaped steel instruments (Fig. 97), adding on small pieces at a time after each successive portion is thor-

Fig. 97.

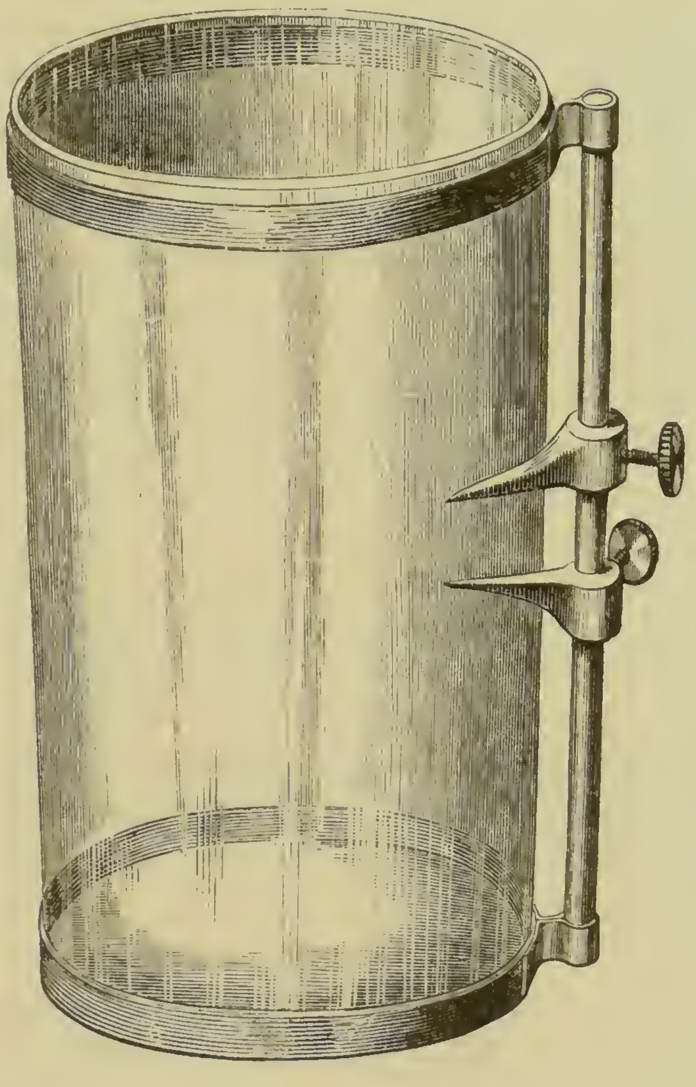


oughly impacted, until the main groove of the matrix over the base of the teeth is partially filled. The palatal convexity of the mold may then be covered with a single piece cut to the form of the uncovered space; a smaller piece of the same general form as the latter may then be added, giving to the central portion a double thickness of the gum plate material, so that when the two sections of the flask are brought together, the excess of gum in the centre will be forced gradually to the margins of the mold, diminishing, thereby, the liability of the grooves becoming prematurely clogged with the material before the opposing sections of the flask close upon each other. Especial care should be taken in the process of packing to avoid contact of the instruments with the surface of the mold, as fragments of the broken plaster are liable to mix with the gum and render the surface of the finished work imperfect by forming small pits wherever such particles occur.

In regard to the quantity of rubber necessary to fill the matrix perfectly, experience in its use will enable the operator to estimate the capacity of the mold with tolerable accuracy. Some small *excess* of rubber should always be provided. The required quantity, however, can be more certainly determined by *measurement* or *weight*. A very simple instrument, (Fig. 98, contrived by Mr. E. T. Starr, may be used to determine

the quantity by measurement. The vessel being partly filled with water, the lower point is adjusted and fixed with a screw to mark its height. Into this every particle of the

FIG. 98.



model plate is immersed, and the rise of water indicated in the same manner by the upper point. The vessel is then emptied and well cleansed, clean water filled in to the level of the lower point, when rubber is added in sufficient quantity to bring the surface of the water on a level with the upper point; to this is to be added the necessary excess of rubber before recommended.

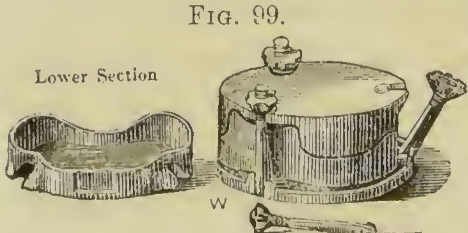
The following method of determining the quantity of rubber by *weight* is given by Professor Wildman:

"The specific gravity of wax is 0·96. I have found that of the American Hard Rubber Company's prepared gutta-percha to be 2·454, and the same company's red rubber to be 1·572. Hence, to fill the mold, when pure wax is used for a model plate, it will require to one part of wax, by weight, 1·6 of the company's red rubber; and when the plate is made of prepared gutta-percha, it will require to one part of it, by weight, ·6 of red rubber. When the wax is colored, the disparity in weight will not be so great as with pure wax.

"Of the two methods to ascertain the quantity of rubber, that by measure offers an advantage over that by weighing, in the facility with which it can be arrived at, especially when Starr's instrument is used, the calculation being based upon bulk only; whilst by weight, when the model plate is composed of more than one substance, as it frequently is, of gutta-percha, wax, and sometimes wires introduced to give stiffness, quite an intricate calculation must be made to ascertain the exact quantity."

Having completed the packing of the mold, the two portions of the flask are re-applied to each other in exactly their original relation, being careful that the apposition of the two is such that, when approximated, the guides attached to one division of the flask shall pass directly and without obstruction into the grooves or slots in the one opposite. With the flasks first introduced, some difficulty and uncertainty were often experienced in effecting the desired closure of the flask on account of inherent defects of construction, but more recent improvements have entirely obviated this difficulty. Those manufactured by Drs. Hayes and Whitney enjoy deserved popularity, and are, perhaps, in most general use. Fig. 99 represents one of Hayes' flasks, with improved clamps. The lug-

Fig. 99.

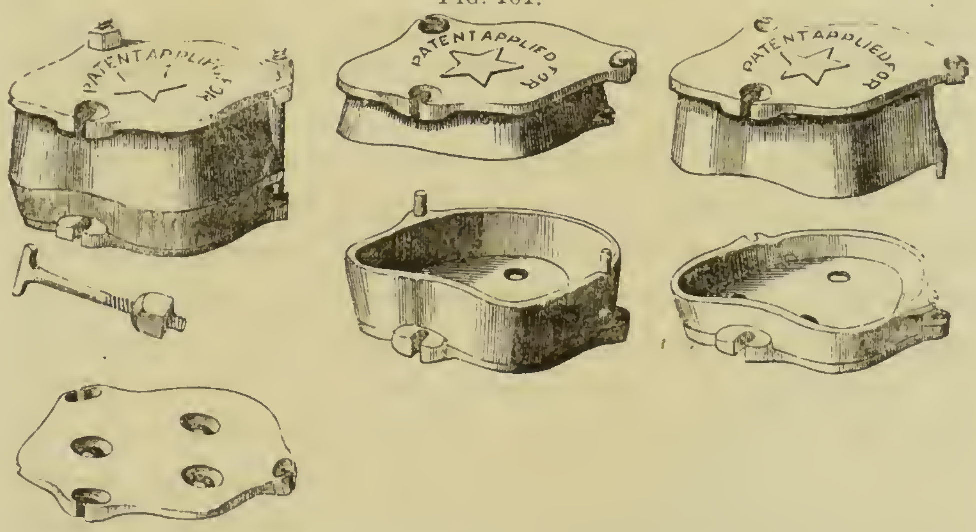


joint is so constructed that the strain all comes upon the casting. The pin only serves to keep the lug in place while not in use. The several pieces all being attached together, are not liable to get lost or mislaid. Whitney's flasks, original and improved forms, are shown in Fig. 100. The improvement in construction consists in reversing the position of the bolts, fitting the head into the hole in the lower part of the flask, and using a nut on top.

FIG. 100.

What is known as the "Star Flask" is highly commended as fulfilling very perfectly the requirements of practice. An admirable flask, happily meeting some important indications, is represented in Fig. 101. Every operator of experience is

FIG. 101.



familiar with the annoyance and difficulty sometimes attending a satisfactory adjustment of models of unusual depth, often of lower sets, and partial pieces, where the porcelain teeth are secured by the surrounding plaster to the model—difficulties arising from the shallowness of the lower section of flasks as ordinarily constructed. The "*Reversible Flask*," invented by Mr. E. T. Starr, the different parts of which are represented in the accompanying cuts, provides very perfectly

for any exigency that may arise in the class of cases mentioned. The following description of this flask is taken from the advertising columns of the *Dental Cosmos:*

"The rings of this flask are of different widths, either of them fitting the top or bottom accurately, as may be required.

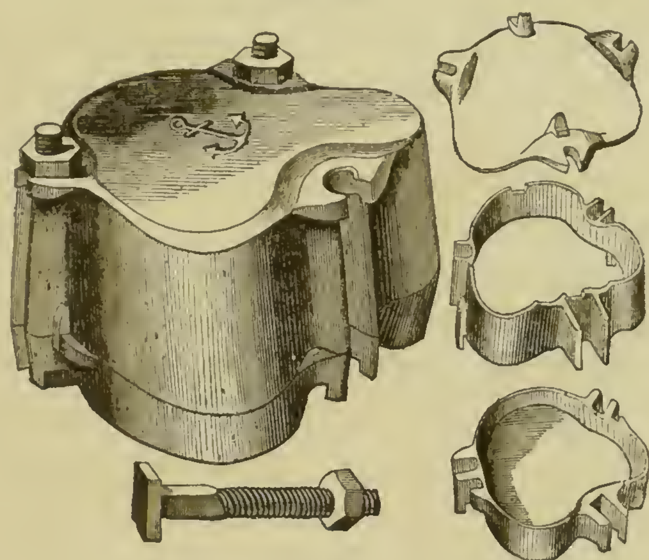
"By using the wide ring next to the bottom, an admirable flask is obtained, for deep cases and partial sets, or where the artificial gum rests on the natural. The narrow ring is used next the bottom plate, for whole dentures, where the parting is at the rim of the plate. The bottom has three counter-sunk holes, through which the plaster runs, and, when set, holds the accompanying ring securely to it. The fastenings of the flask are T-shaped at one end, and fit the slots in the bottom plate; and, being free at both ends are more easily adjusted than ordinary bolts. The flask being in four pieces (two rings and two plates), the plaster is removed without the usual trouble. The cuts represent the flask in different positions."

The author has, for the past two or more years, used exclusively, and with the greatest satisfaction, a flask constructed with detatched T-shaped bolts fitting accurately into slots or grooves extending continuously from top to bottom of the flask, as represented in Fig 102. The closure of the sections by this arrangement, with the bolts in place, is unerring, and is accomplished with the greatest facility. It is called the "*Anchor*" flask, furnished by the Philadelphia Dental Manufacturing Company, but the author is unadvised of the name of the inventor.

Whatever flask is used, the entire mass of enclosed rubber should be rendered uniformly plastic, after packing, by subjecting it to either a dry heat, such as may be obtained with a conveniently constructed sheet-iron furnace, the baking apartment of an ordinary cooking stove, or any other available means by which a diffused and uniform temperature may be secured, being careful not to over-heat; or, if moist heat

is employed, by immersing the flask in boiling water for a time sufficient to soften the rubber. The approximation of

FIG. 102.



the sections of the flask should be effected interruptedly,—alternately heating the entire mass and tightening by means of the screw-bolts until all the redundant material is expelled by degrees through the outlets provided for it, and the sections of the flask close accurately upon each other.

A somewhat novel and ingenious device employed in packing the mold is exhibited in Fig. 103, known as "Hayes' Condensing Flask."

FIG. 103.

To form the mold, first smear over the plunger with soap, put it into the flask and secure it in place by a turn of the set-screw. Pour in the plaster and place the model in the usual way, allowing the plaster to flow up and take the imprint of the lower half of the plunger. When the teeth are in place the back edge of the plate must be connected with the plunger by a broad strip of wax reaching across its entire face, to form a gateway, or, if an under set, two strips con-

necting the plunger with the mold on each side opposite the molar teeth. These strips may be thickened a little where they connect with the plunger, to allow a free flow of rubber into the mold. Also lay a narrow strip of wax from the mold to the notch in the front edge of the flask, from which the rubber will protrude and show when the mold is full. Then put on the upper section, fill with plaster, and drive on the cover before the plaster sets.

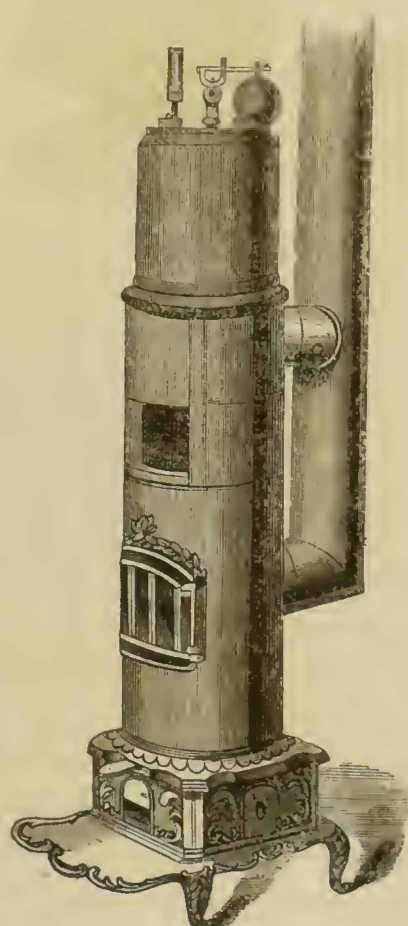
When hard, first withdraw the plunger, then open the flask and remove the wax in the usual way. Take once and a half as much rubber by measure, or three times as much by weight, as there was of the wax. There is no occasion to warm either the mold or the rubber. Cut into strips, lay as much into the mold as may be without preventing the flask from closing, and place the balance within the cavity formed by the plunger. Now close the flask, again smear the plunger with soap and press it into the flask as far as it will go. Then connect the flask with the screw-press, turn down the set-screw firmly upon the flask, and place the whole in the open vulcanizer two-thirds filled with water. When it boils freely, turn down the screw—not faster than one revolution a minute—till rubber appears at the opening in front left for that purpose.

Should there be a surplus of rubber, it may be withdrawn with the plunger, by leaving the end without soap; or it may be left in and removed with the plaster after the piece is vulcanized. In either case there is no need of closing the cylinder while vulcanizing, as the rubber in the mold will not be displaced. If desired, however, the cylinder may be filled with plaster or a cork. Should the plunger be used without soap, the rubber will adhere somewhat, but will do no harm, as it is easily removed by a cloth moistened with kerosene or naphtha. In driving on the cover, or removing it from the flask, a few light blows with a small mallet serves the purpose best, and will not batter the metal.

The packing accomplished the piece is ready for the vulcanizing process.

Vulcanizing.—The process of vulcanizing or hardening the various rubber compounds employed for dental purposes, is effected by subjecting them for variable periods of time to the action of heat, the substances to be acted on being confined within a steam-chamber constructed for the purpose. The time and temperature necessary to produce the requisite induration differ with the various compounds in use, and, to some extent, are influenced by the kind of vulcanizing apparata employed and which present various modifications of form and mechanism, being constructed, in part, with reference to the source and mode of application of the heat, the latter being derived either from coal or charcoal, or other solid combustible substances, or from the flame of a spirit lamp, gas, or coal oil or some of its products.

Fig. 104.



When fuel is used, the form of vulcanizer shown in Fig. 104, may be employed. It consists of an open-topped, cylindrical stove surmounted by a cast-iron boiler and steam-chamber, in the latter of which the flask is placed. To the top of the steam-chamber is attached a thermometer and safety-valve, the former to indicate the degrees of heat produced, and the latter to regulate the same and provide against explosion. In front of the stove are two openings with doors, and a ventilator communicating with the ash-pit; on the opposite side are two flues. By opening or closing one or more of these several passages, the heat evolved may be

regulated and controlled. The capacity of the steam-chamber connected with the coal stove vulcanizer is sufficient to receive from four to six cases at a time. Very great improvements, however, in the form and construction of vulcanizers have been made within the past few years, and which have almost, if not entirely, superseded those heated by fuel. These are adapted to either gas, alcohol, or coal oil and its products, for heating purposes. Fig. 105 represents one of Dr. Hayes'

Fig. 105

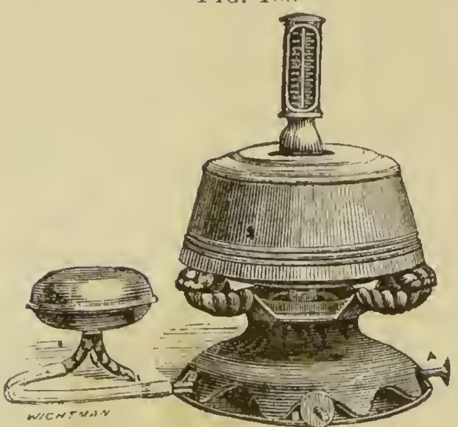


Fig 106

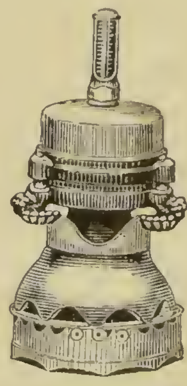
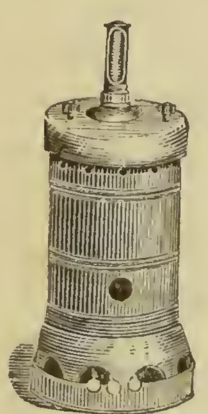


Fig. 107.



Single Flask Iron-clad Ovens, convenient and compact in form, and capable, it is claimed, of vulcanizing in 40 minutes at a temperature of 320°, with one ounce of alcohol. Instruments of similar construction are produced by the same manufacturer with a larger boiler capacity for from one to three cases, Figs. 106, 107.

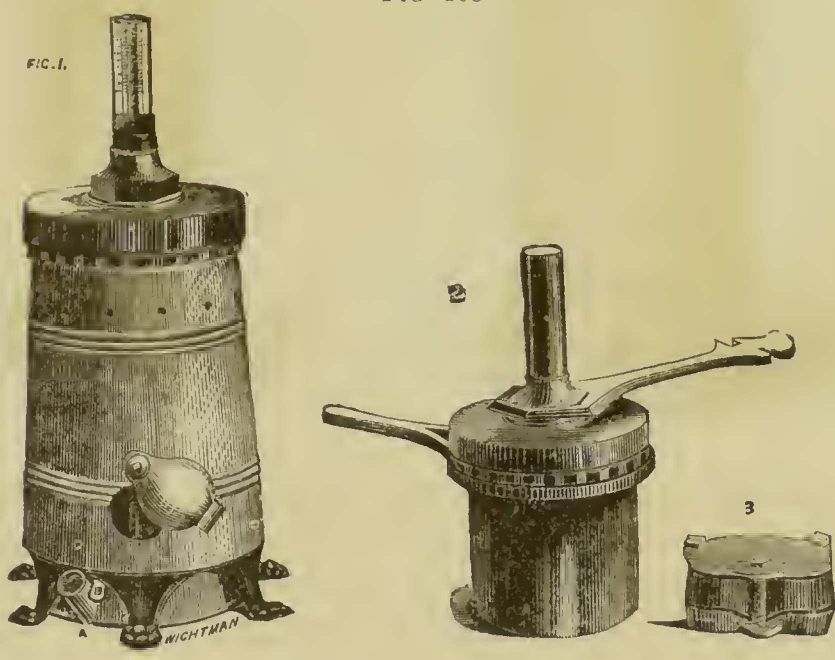
The iron-clad improvement in these machines is designed as a protection from the dangers of explosion consequent upon a gradual thinning of the copper boiler from corrosion, a safeguard of great practical value and concern to those who are continually exposed to the perils of such an accident. The shell is made of malleable iron, $\frac{1}{8}$ inch thick—strong enough to resist many times the strain required; and can never be exposed to deterioration. The copper lining is made the same thickness as the copper boilers now in use, and the machine may be used with perfect safety, even when the copper has become as thin as paper, and then, when an opening has been

fairly eat through, steam will escape from between it and the iron shell, below the packing joint, giving timely notice that a new lining is required, which can be inserted at moderate expense, and render the vessel good and safe as new.

A peculiar and important feature of these vulcanizers is in placing the thermometer bulb within a mercury bath, outside the steam-chamber, relieving it entirely from the danger of being crushed or checked by the pressure of steam, as is liable to happen when it is exposed to the steam itself, necessitating its frequent replacement.

A not less convenient, safe, and reliable vulcanizer is that known as Dr. Whitney's, represented in Fig. 108, having a

FIG 108

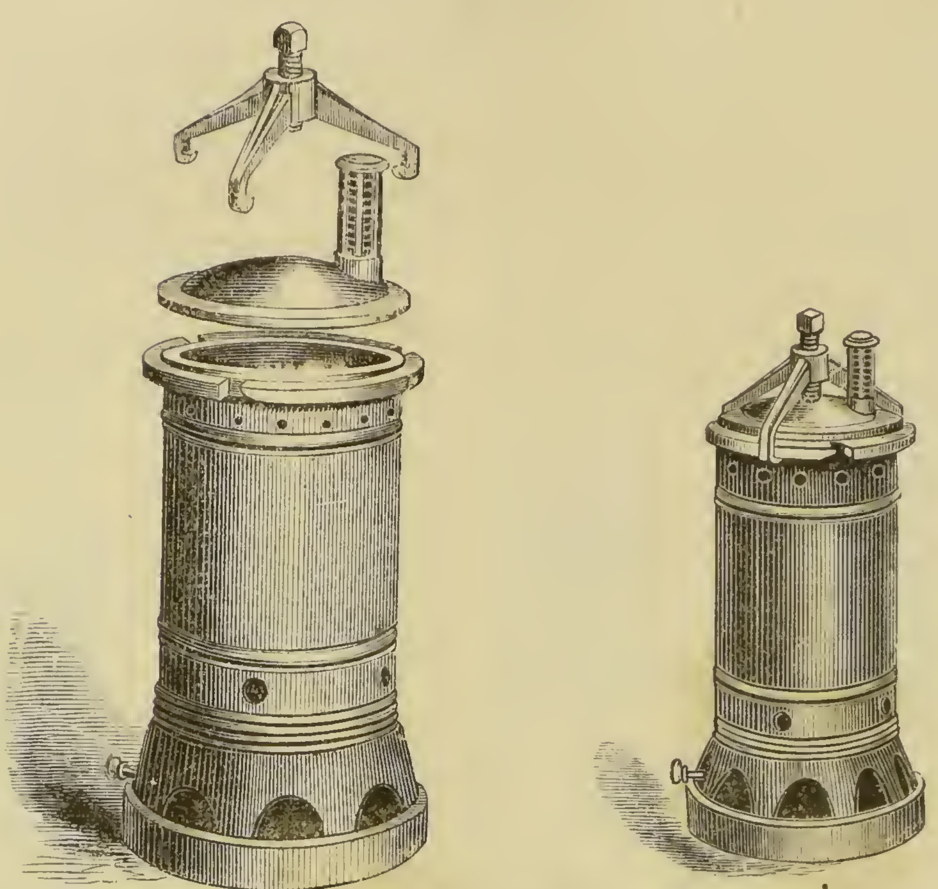


steam-chamber capacity for from one to three flasks. The boiler is made of wrought copper; the top or cap, which is screwed on, being provided with a thermometer, and an aperture filled with fusible metal, which renders explosion of the boiler, unless materially weakened by corrosion, impossible. The author has had one in constant use for more than three years without any perceptible deterioration.

A well approved instrument, called the "Buckeye Vulcan-

izer," invented by Dr. C. H. James, of Cincinnati, Ohio, is exhibited in Fig. 109. The mechanism of this instrument is

FIG. 109.



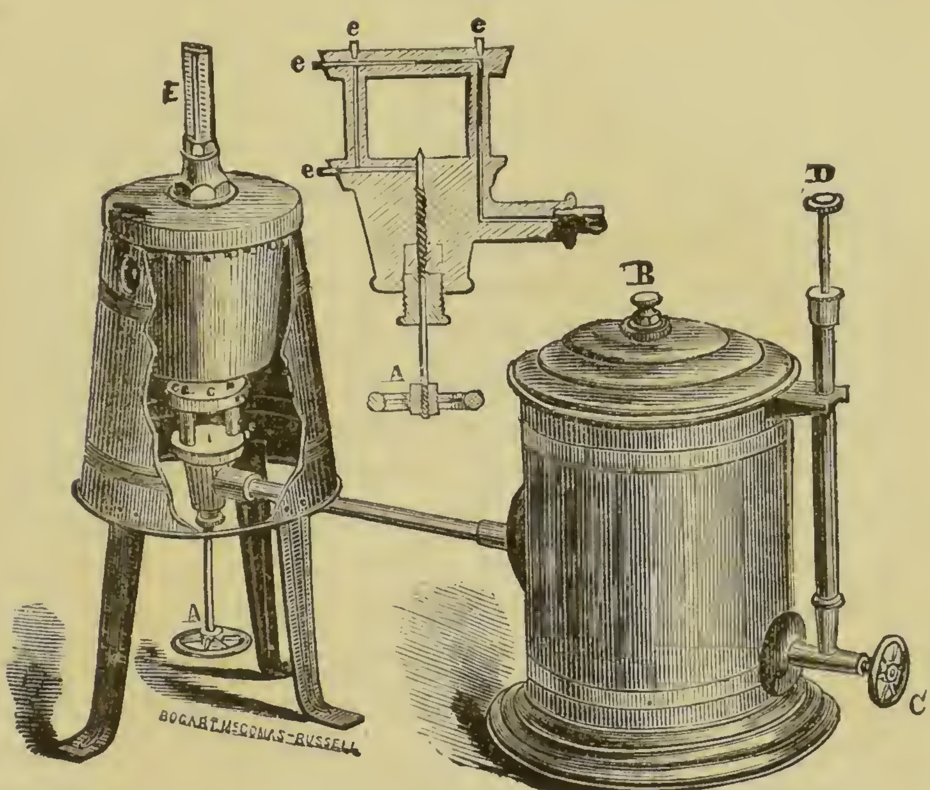
remarkably simple and ingenious, the relation of the different parts being plainly exhibited in the accompanying cuts. The top is very quickly and readily adjusted, and is clamped and held securely in place, making a steam-tight joint, by a single set screw acting upon the centre of the cover.

The application of heat derived from coal oil and its products, for the purposes of vulcanizing, is shown by the accompanying cut, (Fig. 110,) which represents what is advertised as "*Hull's Petroleum Gas Burner*," and which the inventor claims is "a lamp by which coal oil and its products can be substituted for gas or alcohol for heating purposes. This apparatus will burn BENZINE with perfect safety, and with greater heat than either gas or alcohol, and

free from smoke. The cut will show its adaptation for vulcanizing, and can be used for any other purpose. There is an attachment for a compound blowpipe."

Whatever form of vulcanizing apparatus is used, or means

FIG. 110.



of heating adopted, the flasks are introduced and sufficient water poured in to cover them. If the flasks are hot when placed in the boiler, water of nearly the same temperature should be added to avoid fracturing the teeth. Before screwing on the cap, the rubber packing should be dusted with whiting or pulverized soap-stone to prevent adhesion. As it is very important to secure a steam-tight joint, the packing should be of uniform thickness, firm, and securely fixed. The webbed rubber is the best for the purpose. In arranging a new packing, cleanse well the groove in the boiler which receives the rim of the cap, and fit the packing accurâtely. Before screwing on the top, dust the surface of the packing as before recommended, and as the heat rises

tighten the screw from time to time until the rubber no longer yields. If the latter precaution is not observed, the packing is either liable to blow out, or the joint leak steam. To insure uniform results, it is necessary that there should be absolutely no leakage.

When the flasks are properly secured within the steam-chamber, heat is applied and continued until the requisite induration of the gum is effected. The time and degrees of heat necessary to effect this result differ somewhat with the rubber compounds and kind of vulcanizer employed. The heat should be raised gradually until the thermometer indicates the proper vulcanizing temperature, when the flame should be lowered and the heat maintained at this point until vulcanization is completed. In all cases it is best to raise the heat slowly until it reaches 320°, which temperature should not be attained in less than from one-half to three-quarters of an hour. Where there is any considerable or unusual body of rubber, the time taken to raise the heat to that point should be extended to one hour or longer, for if the mass is heated too rapidly, porosity or sponginess of the thicker portions of the rubber will almost certainly ensue. This result would seem to be due to the energetic evolution of sulphuretted hydrogen gas under a quick heat, the proper elimination of which is checked and the gas confined within the body of the mass by a too rapid surface induration of the rubber. The evolution of this gas is demonstrated by Prof. Wildman in the following experiment:

"To ascertain if sulphuretted hydrogen is given off during vulcanization, a bulb was blown at the end of a glass tube, this was filled with red rubber, the tube was then drawn out very small from immediately above the bulb, and curved so that the small part when the bulb was in the paraffin bath could be inserted into a vessel beside it.

"The bulb was then placed in a paraffin bath, and the curved end of the tube inserted in a vessel containing a solution of acetate of lead. The heat was raised to 320° F., and retained at that point for one hour and a quarter.

"The mean results of several experiments conducted in this manner was, that during the first thirty or forty minutes after the heat had attained to 320°, bubbles of sulphuretted hydrogen came over at short intervals, and at the expiration of this time it was evolved in a continuous stream which continued for a few minutes, causing a copious precipitate of sulphide of lead. After this, until the expiration of the hour and a quarter, the gas was only given off sparingly at intervals. This experiment gives us ocular demonstration that this gas is evolved during vulcanization, and in large quantities, and conclusively shows that in thick pieces, especially, the heat should be slowly raised, and the rubber should be under strong pressure to insure a successful result."

When the American Hard Rubber Company's red rubber is used, the heat should be maintained at 320° for about one hour and ten or twenty minutes. Induration may be effected at a lower heat, but the time must be proportionally extended; or a higher heat being employed, a less time will be required to vulcanize. With the use of the rubber mentioned, the author has obtained good results by vulcanizing for 45 minutes at 340°. Care, however, should be taken not to over-heat, as the rubber is thereby rendered dark and brittle, and the important property of elasticity impaired. The time and degrees of heat first mentioned, therefore, may be regarded as the safest, and as yielding the best results, though with other rubber compounds, and the use of modified forms of vulcanizers, corresponding differences in time and temperature may be required, and which can only be accurately determined by vulcanizing test pieces of rubber.

In this connection the reader's attention is called to some practical observations on the subject of steam pressure in vulcanizing, and the reliability of thermometers as indicators of heat, and which acquire additional interest if it be true, as alleged, that many of the vulcanizers in use by dentists are insecure, by reason of inherent defects of construction, or faultiness in the modes of indicating the elastic force of

steam. In commenting on this subject, Professor Wildman observes:*

"As high steam is used in vulcanizing, it is important that the operator should be conversant with the nature of the agent which he employs to accomplish his end. It is perfectly safe; but the following will show him that it must be used with discretion and judgment. Numerous experiments have been made by scientific men to ascertain the elastic force of steam at different temperatures. The results of their investigations are not uniform; although they all agree in showing the immense force exerted by this agent at high temperatures. Haswell's tables are looked upon as good authority. The results of the investigations of the Franklin Institute Committee, in the higher degrees, give a greater elastic force than the table below quoted. I shall, however, quote the results of the experiments of the commission of the French Academy, appointed by the French government to investigate this subject, for the reasons that, from the manner in which they were conducted, they are probably as reliable as any, and that they are extended to a more elevated temperature than the others.

Elasticity of steam, taking atmospheric pressure as unity.	Temperature F.	Pressure per square inch, lbs.	Elasticity of steam, taking atmospheric pressure as unity.	Temperature F.	Pressure per square inch, lbs.
1	212°	14·7	8	341·78°	117·6
1½	233·96°	22·05	9	350·78°	132·3
2	250·52°	29·4	10	358·88°	147
2½	263·84°	36·75	11	366·85°	161·7
3	275·18°	44·1	12	374·00°	176·4
3½	285·08°	51·45	13	380·66°	191·1
4	293·72°	58·8	14	386·94°	205·8
4½	300·28°	66·15	15	392·86°	220·5
5	307·05°	73·5	16	398·48°	235·2
5½	314·24°	80·85	17	403·82°	249·9
6	320·36°	88·2	18	408·92°	264·6
6½	326·26°	95·55	19	413·78°	279·3
7	331·70°	102·9	20	418·46°	294
7½	336·86°	110.85			

"I would here call the attention of those using high steam

* Instructions in Vulcanite, p. 26.

to an important consideration. In raising steam, *the ratio of increase of pressure or elastic force is far greater than that of the increase of temperature.*

"By referring to the above table, commencing at 212° and taking steps as near fifty degrees as is given in the ascending scale, we find this exemplified. Thus:

					Increase of temperature.	Increase of force per square inch.	Giving a force per square inch.
From	212°	to	263·84°	=	51·85°	22·05 lbs.	36·75 lbs.
"	336·84°	to	314·24°	=	50·40°	44·10 lbs.	80·85 lbs.
"	314·24°	to	366·85°	=	52·61°	80·85 lbs.	161·85 lbs.
"	366·85°	to	418·46°	=	51·61°	132·15 lbs.	294 lbs.

"This comparison shows clearly how rapidly the pressure increases at high temperatures, and warns the operator that a strong instrument, combined with care and judgment in its treatment, are indispensable to safety. Besides the rapid increase of pressure, it must be borne in mind that, at high temperatures, copper, of which the boiler is composed, becomes weakened, and in a measure loses its power to resist this great imprisoned force. Copper, in passing from 212° to 230° F., loses about one-tenth of its strength, and at 550° it has lost one-fourth of its tenacity."

In a paper read before the Massachusetts Dental Association, January, 1865, Dr. A. Lawrence affirms that "Most vulcanizers are now made of sheet copper one-sixteenth of an inch in thickness, and, agreeable to the foregoing facts, have a tensile strength of 1,875 lbs.; and one four inches in diameter will not sustain a pressure of more than 150 lbs., per square inch, or a temperature of 363°.

"Let us next ascertain what force of steam is exerted upon the boiler within a short range of temperatures. We find by the tables of Haswell, King, and others, that at 320° the pressure is 85 lbs.; at 324°, 90 lbs.; at 328°, 95 lbs.; and at 332°, it is 100 lbs. per square inch. These figures I have verified by a steam gauge connected with my own vulcanizer, and which I now use in preference to the thermometer, as I

consider it more convenient, safer, and less liable to accidents.

"Practical engineers concur in the opinion that a force of not over one-half the sustaining capacity of the boiler can be safely applied."

The logical deduction from these statements is plain. If a boiler four inches in diameter, constructed of sheet copper one-sixteenth of an inch thick, will not sustain a pressure of more than 150 lbs. per square inch, and, accepting as true what is affirmed by practical engineers, "that a force of not over one-half the sustaining capacity of the boiler can be *safely* applied," then every operator who, with the use of such an instrument, vulcanizes at a heat of 320° is in hourly jeopardy of life and limb.

Intimately connected with the process of vulcanizing is the question of the reliability of thermometers as *indicators* of heat, or steam-pressure. Dr. Lawrence, commenting on this subject, says: "Suppose the bulb of the thermometer gets slightly fractured, and, the accident not being discovered, the vulcanizer is put to use, what then?

"If the damage is slight, the mercury may still be made to rise in the tube at high temperatures, but will not truly indicate the full heat or force within. Some time ago, I had some difficulty in producing a desirable shade in my vulcanite work; it was too dark, as is the case when overheated, and I came to the conclusion that the gum had deteriorated in quality. Other samples of gum were tried, and at varying lengths of time, yet with the same result.

"No defect could be discovered in the thermometer by the naked eye, but a microscope revealed a slight crack in the bulb, and the mystery was solved. But what force of steam was produced during these almost despondent trials?

"Although my vulcanizer would safely bear a pressure of one hundred pounds per square inch, I concluded to use a steam gauge for the future, and now feel a security in its use positively refreshing."

The unreliability of thermometers, in connection with vulcanizers, has been recognized by many in the profession who have testified to their uncertainty and insecurity as a means of determining with exactness at all times the amount of steam-pressure employed in the process of vulcanizing at a high heat. The *steam gauge* (Fig. 111), spoken of by Dr. L. seems very perfectly to fulfill the requirements of the dentist, and may justly claim favorable consideration from the commendation bestowed upon it by the distinguished gentleman who has brought it to the notice of the profession. The following is the author's own account of the instrument: "The gauge most suitable for the purpose in question, somewhat resembles a small circular clock; is about six inches in diameter and marked to register one hundred and forty or one hundred and eighty pounds pressure, with pound dots near the outer circle of the dial. A pointer indicates the force which moves it.

"This size is better than a smaller one, because the spring inside not being crowded to its utmost capacity in vulcanizing, will, of course, retain its working integrity longer; in fact, as long as any dentist now living will be personally interested in the matter. The price of such a gauge, at this time, is $18; and, though more expensive ones can unquestionably be made, they are no more reliable, the difference consisting in mere 'outward show and adorning,' They can be used with all vulcanizers generating steam, connecting by means of three or four feet, or as much more as may be convenient, of small pipe having a U-shaped bend, or a single coil near and under the gauge to receive the condensed steam, as water alone should enter that instrument.

"The following table exhibits a range of pressures sufficient for vulcanizing purposes, with the temperatures necessary to produce the same.

Pressure in pounds.	Temperature.	Pressure in pounds.	Temperature.	Pressure in pounds.	Temperature.	Pressure in pounds.	Temperature.
60	295°	69	305°	78	314°	95	328°
61	296°	70	306°	79	314°	100	332°
62	298°	71	307°	80	315°	105	335°
63	299°	72	308°	81	316°	110	339°
64	300°	73	309°	82	317°	115	342°
65	301°	74	310°	83	318°	120	345°
66	302°	75	311°	84	319°	125	349°
67	303°	76	312°	85	320°	130	352°
68	304°	77	313°	90	324°		

"It will readily be seen by the above, that a pressure of sixty pounds requires a temperature of two hundred and ninety-five degrees by Fahrenheit's scale to produce it, and eighty-five pounds three hundred and twenty degrees, at which latter pressure I vulcanize, running one hour, and with the most satisfactory results.

"The manner of putting up and using the gauge is very simple. All that is required is to secure it, by screws passing through the flange on the back, in some conspicuous and convenient place, attach a pipe and carry it down ten or twelve inches, give it a bend or curve upward about half its length, or five or six inches, thence at right angles or otherwise, and in any convenient length not less than three feet, to the vulcanizer.

"The annexed cut is from a photograph of a Whitney vulcanizer with the gauge attached, but is by no means the only arrangement which can be made, as, in some cases, convenience may require more pipe, or a different distribution.

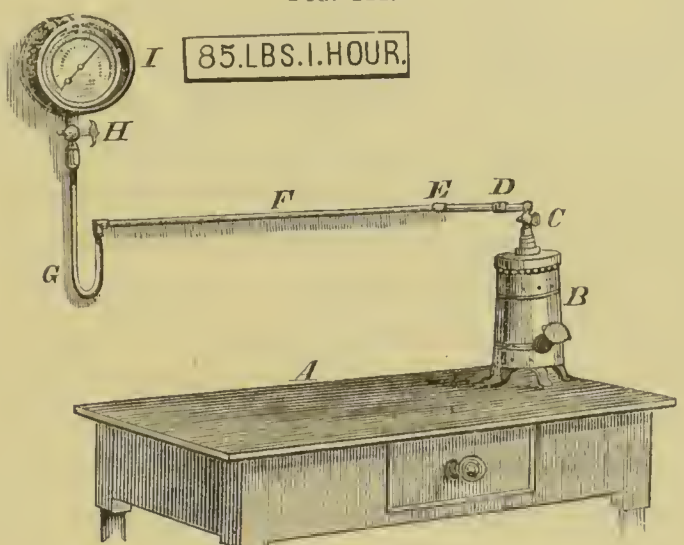
"A, table or work bench; B, vulcanizer; C, side outlet pendant cock screwed on in place of the thermometer scale; D, coupling joint; E, angle in the pipe; F, iron pipe three-sixteenths inside; G, U-shaped curve five or six inches in depth; H, cock to the gauge; I, gauge.

"The fitting, putting up and arranging the entire apparatus can be done in an hour's time by any gas fitter, or, to those residing away from cities or towns where such mechanics are employed, can be furnished to order by them, or by the parties furnishing the gauge.

"All the joints, from the vulcanizer to the gauge, except the coupling, should be 'leaded' with very thick lead paint, and screw together steam tight.

"In using the apparatus, the cocks C and H must be turned

FIG. 111.



straight with the pipe, for if shut off at either point, the gauge can not be acted upon by the steam. I generally heat the water in the vulcanizer nearly or quite to the boiling point, and let off the heated air by turning, or allowing to remain open, the cock C, then connect at the coupling D, turning the nut tight (not too tight) with a wrench.

"So soon as steam begins to form, it is condensed by contact with the cold part of the pipe, and falls into and fills the curve or coil with water which is then forced into the gauge with a power indicated by the pointer on the dial. The pipe should descend a trifle from the angle E to the commencement of the curve, to facilitate the passage of the condensed steam to that point.

"Although vulcanizing one hour at eighty-five pounds affords results satisfactory to me, others may prefer a different time with more or less heat.

"The table will be found a guide in such cases.

"When the time is up, discontinue the fire, and shut off

the steam by turning the cock C. Turn the cock H in the same manner, to prevent a too sudden reverse movement of the machinery of the gauge, the pressure on which should be gradually relieved at any convenient time.

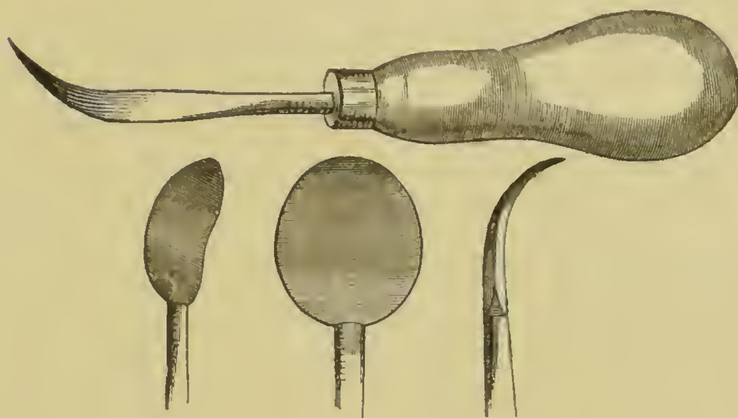
"Now disconnect by unscrewing the coupling and dispose of the steam in the vulcanizer by blowing off, or any other means preferred. Further remarks would seem unnecessary to a full understanding of the subject. Having used the gauge almost every day for about six months, I am fully satisfied that it is a decided improvement in vulcanizing, and am so delighted with it that no reasonable sum would induce me to substitute the thermometer."

When the process of vulcanizing has been conducted a sufficient length of time, the flame is turned off and the steam discharged through the safety-valve, if the vulcanizer is provided with one; or the lower half of the boiler may be placed in cold water until the contents are cooled down to about 200°. When time will permit, however, it is better to let the vulcanizer cool gradually. The top is then taken off and the flasks removed. The latter should always be allowed to cool gradually, as the immersion of the flask, while hot, in cold water will endanger the porcelain teeth by a too sudden change of temperature. Neither should the flask be opened while hot, for the plate being pliable when heated, would be liable to suffer some change of form in forcing the sections of the flask apart, or in removing the piece after separation of the flask. When the plate is removed from the flask, detach carefully all adhering plaster with a pointed knife, and cleanse well by washing with a stiff brush.

Finishing.—The rougher and more redundant portions of the indurated material are first removed with coarse files or rasps, following with those of a finer cut until all parts of the piece accessible to such instruments are reduced to nearly the thickness required. The excess of material on the lingual side of the plate and other points not admitting of the use of the file, is removed with scrapers of various forms,

some of which are shown in Fig. 112. After nearly the desired thickness is thus obtained, and the surface rendered

Fig 112.



somewhat smooth and uniform, a still further reduction is obtained with the use of sand-paper, using first the coarser and finishing with the finer kinds. The final polish is then given to the surface, first with the use of finely pulverized pumice stone, and afterwards with either prepared chalk or whiting. The best method of applying the pumice is with flat circular pieces of cork of various sizes, which may be readily formed by attaching them to the lathe and reducing them to the proper size and shape with a file while revolving. The chalk or whiting may be applied upon a cotton or ordinary brush wheel. In the use of the polishing materials, the latter should be kept constantly and freely saturated with cold water throughout the operation.

Partial Dentures Constructed in a Base of Rubber.—The foregoing description of the method of forming entire dentures in a base of indurated gums, together with a knowledge of the manner of constructing parts of sets of teeth mounted on metallic plates, will render any extended description of the former process, as it relates to partial pieces, unnecessary. A gutta-percha plate of the required thickness and dimensions is accurately molded to a model of the parts, the narrower portions passing into the spaces between the teeth

being stiffened by doubling the plate at these points with an additional strip of gutta-percha warmed at the lamp and made to adhere to the primary plate. The central portion of the plate may also be temporarily supported, and its form preserved, by filling in the concavity with a layer of stiffened wax. A rim of wax is then attached in the usual manner to those portions of the plate occupying the vacuities on the ridge, when the plate is placed in the mouth and an impression of the points of the opposing teeth secured; it is then removed, reapplied to the model, and the heel of the latter extended posteriorly to form an articulating surface for the remaining portion of the antagonizing model,—the latter being formed in the ordinary way. The teeth are then fitted to the vacuities in precisely the same manner as when metallic plates are used, and the wax trimmed to the required fullness. The plate, with the teeth attached, is then placed in the mouth and any necessary corrections made in the arrangement of the teeth; after which it is removed and re-adjusted to the model.

In constructing partial sets of vulcanite, it is of the first importance, when forming the mold, that the relation of the porcelain teeth to the model of the mouth should be accurately maintained, the reasons for which are fully set forth when treating of the formation of the mold or matrix for full sets. To secure this result with certainty the following method should be adopted. Having adjusted the plate and teeth upon the model, with the wax trimmed and carved to the required fullness, place the model in the lower section of the flask and fill in with plaster, extending it up to the points of the teeth, binding them to the model, and making the line of separation of the sections of the flask at that point. The ends of the plaster teeth should be cut away sufficiently to allow of a ready separation of the sections. Plaster is then poured in for the upper section of the mold, and, when hard, the flask is parted and the wax removed from the model and teeth, the latter being retained in the lower instead of the upper section as in full cases.

Metallic Clasps Attached to Rubber Plates.—Although atmospheric pressure should be made available in all practicable cases as a means of retaining parts of sets of teeth in the mouth, yet cases occasionally present themselves, necessitating the employment of clasps. These may be of rubber, but those formed of gold, or gold alloyed with platina, are more reliable and better adapted to those cases where the spaces between the teeth are contracted. The following description of the method of constructing them is given by Prof. Wildman.*

"First bend the clasp to fit the tooth accurately; then make the attachment by which it is to be held to the rubber (this may be done by soldering a thin plate of gold or platina to the clasp in such a position that it will be enclosed in the rubber); then perforate the plate with numerous small holes, which should be countersunk on both sides (Fig. 113). This plate entering the base, the rubber filling the holes forms pins which rivet the clasp securely to the rubber plate.

Fig. 113.

"Or the attachment may be made in this manner. On the parts of the clasp that can be covered with rubber, drill one, two, or three holes, as the space may admit; insert gold or platina wire, solder with gold solder, then cut off at proper length, and head them (Fig. 114); these act in retaining the clasp in the same manner as the double-headed pins in securing the tooth to the base, and offer the advantage over the perforated plate of being more easily manipulated, and less liable to become displaced in packing the mold. The clasp is to be attached to the model plate, and will remain secured in the mold when it is opened."

Fig. 114.

A metallic clasp may also be very securely attached to the rubber by drilling a number of holes in that part of the clasp which lies in contact with the rubber, and countersinking them well on the inside of the clasp.

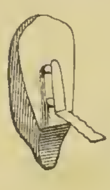
* Instructions in Vulcanite, p. 36.

Substitution of Plate for Rubber Teeth.—An ordinary plate tooth, such as is commonly used in connection with a metallic plate base, can be readily rendered suitable for a rubber base. This is done by soldering a narrow strip of gold plate to the ends of the platina pins, forming a loop or staple (Fig. 115), and which imbeded in the rubber, renders the attachment very secure. A narrow arm of rubber extending to a single tooth may be materially strengthened by permiting the gold strip, perforated with holes or roughened on its edges, to pass some distance into the rubber as seen in Fig. 116.

FIG. 115.

Instead of forming a loop or staple as mentioned, it will be preferable in many cases to solder to the tooth a somewhat wider strip than that represented, in the same manner as ordinarily practiced in backing for gold work, the strip being strengthened by flowing solder at the angel of divergence from the heel of the tooth, and extending thence into the the body of the rubber, perforated or roughened on the edges as before recommended. The rubber in this case may be cut away, when finishing, to the angle, leaving nothing but the strip of gold and sub-lining of rubber at the base of the tooth. This method may be resorted to with signal advantage in those cases where, on closure of the jaws, the points of the opposing teeth encroach unduly upon the space to be filled, extending nearly to the gum, requiring the tooth of replacement as thinly formed throughout its length as possible.

FIG. 116.



Repairing.—If a tooth or block has been broken, or any change is to be made in the position of either, the teeth, or fragments thereof, are removed and an irregularly shaped groove or dove-tail formed in the base occupying the space to be supplied; into this space the tooth or teeth are properly arranged and supported with wax; the dovetail is then filled in with wax, giving some additional fullness to compensate for

waste in finishing. All portions of the piece, except the lingual face of the plate and teeth are then imbedded in plaster in the lower section of the flask. The upper section of the mold is obtained in the usual way. When separated, and all traces of wax removed, the gum is packed into the cavity around the tooth or teeth. Grooves are then cut extending out from the mold; the two sections heated and forced together, and the process of vulcanizing conducted in the usual manner, the same time and degrees of heat being required as in the first instance. The renewed heat employed renders the surface of the material previously vulcanized somewhat darker, to remove which it is recommended to moisten the surface with dilute nitric acid for a short time, after which the piece is thoroughly washed and then placed for a few minutes in an alkaline solution to remove any remaining traces of acid. It is also recommended to immerse the case in alcohol for five or six hours, and then expose it to the rays of the sun for a like period of time.

Refitting Gold or Rubber Plates with Rubber Lining.—Gold or rubber plates, whose adaptation to the mouth has become impaired, in a greater or less degree, by subsequent absorption of the alveolar ridge, may be easily refitted and the adaptation restored by either of the following methods:

First method.—Take, for example, a full upper set on either gold or vulcanite. Secure, in the first place, an accurate impression of the mouth, in its changed condition, in plaster, and from this a plaster model in the manner usually practiced. Perforate the palatal portion of the plate with from eight to twelve holes at different points, and also the external borders, from heel to heel of the plate, at intervals of from one-eight to half an inch apart, and near the edges. These holes may be enlarged to the dimensions of a medium-sized knitting-needle; or if the piece is of vulcanite, to twice or three times that size. On the lingual and buccal surfaces the holes are well countersunk with a bur drill. The plaster model, with the central portion raised to form a chamber,

(and which should be made to correspond, as nearly as possible, in position, form, and thickness, with the chamber in the plate, if one exists,) is next heated throughout by placing it over a spirit flame, or in the baking furnace of an ordinary cooking stove, or the muffle of a furnace, and when of a temperature that will barely admit of being taken in the hand, remove and cover the face of it with a sheet of India-rubber or gutta-percha as prepared for vulcanite work, and press it down upon the face of the model with the fingers. Apply the perforated plate to the model, being careful to secure a proper relation of the two; then press the former down firmly upon the model. To render the vulcanite material still more plastic and compressible, the whole may now be returned to the furnace, and subjected to a uniform heat throughout, when it may be removed, and firm and steady pressure made upon the plate and teeth, until forced, as nearly as practicable, into contact with the face of the model. Portions of gum will be forced through the apertures and out at the borders of the plate; these should be well packed into the countersinks and under the edges of the plate, when the model, with the rubber and plate adherent, may be placed in a vulcanizing flask and encased bodily in plaster. It is then placed in a heater and vulcanized. If all the steps in the process have been carefully conducted, the fit of the plate will be perfectly restored, with no material change in the antagonism, or none, at least, that is not susceptible of ready correction. The union between the vulcanite lining and the plate will be strong and lasting, and altogether impermeable to the fluids of the mouth.

In the case of lower pieces, the holes should be made along the external and internal borders of the plate near the margins. In all other respects the manipulations are the same as those described above.

It is scarcely necessary to observe that, in the use of gold plates, the method is inapplicable whenever it is designed to reswage the same plate for the permanent piece.

Second method.—Perforate the plate, whether of gold, silver, or vulcanite, as before directed; and employing this as a cup or holder, take an impression of the mouth in plaster, pressing the plate up closely to the parts. The plaster forced through the holes, and filling the countersinks on the opposite side of the plate, will serve to bind the plaster to the plate, and prevent, with cautious manipulation, the two from separating as they are being detached from the mouth. When removed, the plaster impression lining the plate is trimmed even with the borders of the latter, and then varnished and oiled. The lower section of a vulcanizing flask is now filled with a batter of plaster on a level with its upper surface, and the impression, filled with the same, is turned over and placed in the centre of the flask, with the edges of the plate touching the surface of the plaster. The plate and adhering plaster are now carefully separated from the model. After cutting out the plaster from the holes and countersinks in the plate, the plaster forming the impression is detached from the plate, and the holes and countersinks filled with wax. The plate is then re-adjusted over the model, and (the surrounding surface of the plaster in the flask having been varnished and oiled) plaster is poured in upon the upper surface of the plate and teeth, filling the upper ring. When the plaster is sufficiently hard, the two sections of the flask are separated, and grooves formed, running out from the matrix to the margins of the flask. A sufficient quantity of vulcanizable rubber is now either placed upon the model or packed in upon the palatal surface of the plate—before doing which, however, the wax filling the holes and countersinks in the plate (and which was placed there to prevent portions of plaster last poured, in forming the matrix, from running in and filling them up) should be worked out with a small instrument. The whole being sufficiently heated, the two sections of the flask are forced together, expelling redundant material. The piece is then vulcanized as in the former case.

The above method, though somewhat more complicated

than the former, is quite simple in its details, and will occupy but little more time, and is, withal, more certain in its results.

Attaching Porcelain Teeth to a Metallic Base by means of Rubber.—The following method of attaching teeth to gold plates with rubber, though not generally practiced, is practicable in very many cases, and possesses advantages over ordinary gold work which entitle it to more favorable consideration and more general adoption than it has yet received. By the process hereinafter described, the warping or changes in the form of the plate, incident to soldering, are avoided; the strain upon the platina pins is lessened by reason of the perfectly adapted rubber socket in which each tooth or block securely rests; the liability to fracture of the teeth from concussion or violence is materially diminished on account of the elastic nature of the attachment; there is a nearer approximation to the natural form of the ridge or gums on the lingual face of the plate; the rubber, penetrating all the joints and openings about the teeth, renders the piece wholly impervious to the secretions of the mouth, making it, in point of cleanliness, equal to continuous gum work; it excels all other kinds of work in the facility with which injury to the teeth may be repaired, and in its ready susceptibility of being entirely remodeled without impairment of the teeth or plate. It occupies much less room in the mouth than rubber plates, and combines, in a large degree, artistic beauty of finish, lightness, and durability.

The method of constructing a set of teeth in the manner indicated, is thus described by Dr. P. G. C. Hunt, whose first successful experiments were made as early as 1859:

"Take the impression, make metallic dies, and form the plate as for work in the ordinary way. After fitting the plate in the mouth, get the articulation, the fullness and length of the teeth, remove the wax and plate from the mouth, and make the plaster articulation. If a full set, after separating the articulation, and before removing the wax from

the plate, take a small light pair of dividers, set them say one inch apart, and with one point following the margin of the wax representing the cutting edge of the teeth, and the other point marking permanently the plaster. Thus you always have in the dividers so set a gauge for the length of any particular tooth. A convenient substitute for the dividers may be formed from a piece of wire of convenient length, one-half the diameter of a common excavator, by suitably twisting its middle for a handle, and its ends being sharpened, and pointing in the same direction, one or one and a half inches apart.

"Thus far we proceed as we do for ordinary gold work. We will now suppose the teeth ground and jointed, leaving as much space between the teeth and plate as the plate will admit of. We next mark with a sharp pointed instrument on the labial surface of the plate each point where it is necessary to place a loop for purposes hereinafter described. Then apply wax to the external or labial parts of the teeth and plate in any manner sufficient to retain the teeth in position, remove the wax from the lingual parts of the teeth and plate, and mark the position on the metal where it is desirable to insert loops, remove the teeth and wax, and with a small bow-drill make holes through the plate at the several points previously determined on for the attachments, about the size of the ordinary plate punch-bole, take of ordinary gold plate, cut in strips, say from a half to one line in width, being governed by the amount of room there is under the base of the teeth, with small, round-nosed pliers, or a wire; bend the strip around, grasp both ends with square-nosed pliers, draw the round-nosed pliers, or wire, as the case may be, still grasping the square-nosed pliers with the left hand, and with a hammer strike the top of the loop a sufficient blow to keep the ends from springing apart. Cut off the ends, and dress down to fit the holes in the plate, after which solder on charcoal or other suitable substance without investment. Pickle, dress and polish that portion of the plate to be ex-

posed to view. Bend and flatten the pins, arrange the teeth according to the articulation, waxing so as to cover up the loops if practicable; the loops should be placed as near the base of the teeth as possible, the rubber forming when finished a part of that general concave shape which is desirable in upper dentures, and which it is not possible to obtain with the ordinary soldered work. Then with silicate of soda paint the joints, to keep the rubber from forcing in where it would show after vulcanizing. Flask, vulcanize, and finish up as usual. The advantages of this style of work are obvious. With this you have work as cleanly as the continuous gum, decidedly more so than the very best single gum or block work soldered in the usual way; again, it is very much stronger, less liable to breakage, both in and out of the mouth, as the rubber gives *a perfect base* and support for the teeth to set upon. By this method *there is no springing of plates.* As your plates fit the mouth when the articulation was taken, so will be the fit when the case is completed.

"On the labial edge of the upper plate the rubber may be allowed to project beyond the edge, if desirable, and it will be found in many cases exceedingly satisfactory to do so, and allow the rubber to be of considerable thickness near the alæ of the nose, where the loss of the cuspidati may leave a want of support to the soft parts adjacent, and which in this manner can be readily corrected. If the rubber extends upwards so far as to irritate the muscular structure, a few minutes will be sufficient to make the necessary alterations. In all such cases where we have control of our patients, we place the denture in the mouth before finally polishing, so as to determine as accurately as possible the limit to which extension upward may be carried.

"The neatest work on this principle is made by carving blocks, giving to the lingual surface that regular concave form which is desirable. In this no platinum pins or loops are necessary, but that half of the matrix on which the blocks are carved, large metallic pins are so arranged as to be hid

from view in the tooth body. Different sized pins may be used, as large as the nature of the case will admit. In short, we make the holes in the block similar to those in pivot teeth, where there is not sufficient room in the block above the tooth (or below if an under) to allow the pins to run into the body of the teeth. After burning, grinding, and fitting, get the position of the holes in the blocks relative to the plate, and drill through the plate as before, and instead of loops, solder gold wire of suitable size and length, say a very little shorter than the depth of the hole in the blocks, and two-thirds the diameter thereof; the wire should have a screw thread cut on it, or that which is just as good, and more expeditious, barb or cut with a sharp knife. At this point of the manipulation, if it is desired that the rubber should extend beyond the labial or buccal edge of the metallic plate, place as many loops at different points as are sufficient to retain it with firmness, after which polish the plate, wax, and proceed as before described. If you desire no rubber beyond the blocks, the roughness of the holes in the same, and the barbed points on the gold wire when properly packed and vulcanized, will give ample strength and firmness to the case, and if care has been used in the entire manipulation, you will have, when finished, but a thin line of rubber exposed to view.

"In partial cases, if of gold base, we solder on loops, as before, for the retention of the teeth, and if there are to be *any clasps*, make them of rubber, uniting them, as the teeth, with loops. If the ordinary plate teeth are used, it is frequently necessary to back them, to give better retaining points for the rubber. If blocks are to be burned, insert loops of platinum plate in the shape of the letter U in place of the platinum wire pins. In consequence of the affinity of the sulphur in the vulcanite for silver, plates of that metal should not be used."

Manner of Obtaining an Exact Duplicate of a Set of Teeth on Rubber.—When, from accident or other causes, a

rubber set becomes broken, or its integrity otherwise impaired, necessitating an entirely new plate with an exact reproduction of the arrangement and articulation of the teeth, the following method, described by Prof. Wildman,* may be pursued with an absolute certainty of success. "Roughen the palatal surface of the rubber, to cause the plaster to adhere to it; then use it as an impression cup to take a plaster impression, being careful when it is in the mouth to preserve the articulation. In this impression cast the model, trim, cut keys or conical holes at several points in its outer face. Now, before separating the impression from the model, make a cast of the face of the teeth in two or three perpendicular sections, extending to the base of the model, using a solution of soap or other parting substance on the plaster mold. Remove this mold of the face of the teeth, which indicates their true position relative to the model; then take the impression from the model. By the aid of heat sufficient to soften the rubber, remove the teeth from it. Next make a model plate with prepared *gutta-percha*. Now secure the sections of the mold of the face of the teeth to the model (their place will be indicated by the keys); adjust the teeth in their proper positions in the plaster mold of them, and build up with gutta-percha or wax to the proper form of the model set. This being done, test its accuracy of contour and articulation by placing it in the mouth. Then, using the model, proceed as for making a new set."

It will be observed that the above process contemplates the necessity of the patient's presence to secure, in the first instance, an impression of the mouth, and again for a trial of the teeth in the mouth to test the accuracy of arrangement, etc. This procedure is rendered necessary in all cases of faulty adaptation of the primary plate, but where the adaptation is satisfactory, and it is desired to construct a duplicate set in all respects precisely like the original, the following method, in the main the same as the one just described,

* Instructions in Vulcanite, p. 40.

may be adopted in the absence of the patient. Oil, or coat with a solution of soap, the palatal surface of the plate to be duplicated; into this pour plaster for the model; trim to the edges of the plate, and give the usual form to the body of the model; form conical holes in the same and secure sectional molds of the outer faces of the teeth in the manner described by Prof. W. When hard, remove these sections and detach the model from the plate. Many cases will admit of a ready separation; in others it will be found impossible to force them apart without fracturing the model. To avoid such an accident, the model may be cast in sections, the latter being bound together afterwards in their proper relation to each other. But a better plan is to heat the model and plate sufficiently to render the rubber soft and pliant enough to be removed without injury to the model. Cases not admitting of the successful application of either of these expedients must be treated in the manner described by Prof. W., that is, by securing an impression of the mouth. After the separation of the model and plate, the manner of conducting the subsequent steps of the operation is precisely the same as that described in the preceding method. The author has adopted the above process in a number of instances with the most gratifying success in cases of defects or accidents to the original plate, and where the presence of the patient could not be conveniently commanded.

CHAPTER XVI.

CHEOPLASTIC METHOD OF MOUNTING ARTIFICIAL TEETH.

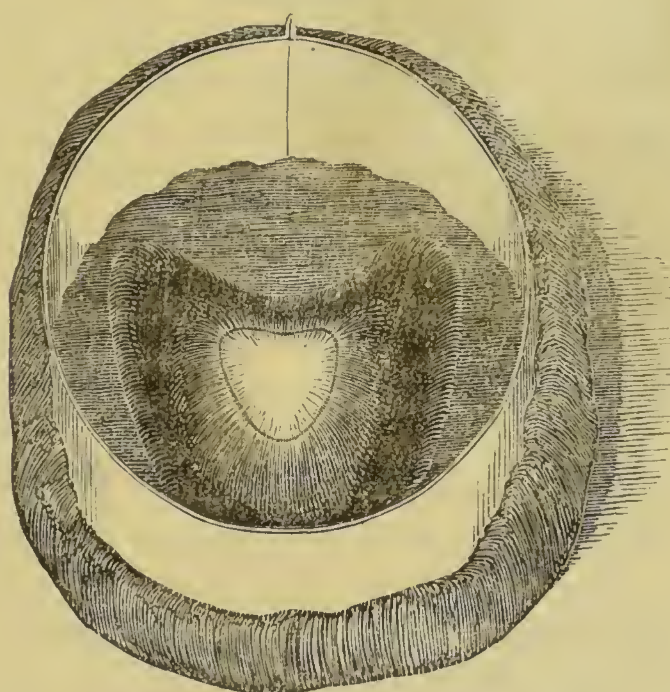
THE method of mounting artificial teeth indicated by the above caption is one of comparatively recent introduction, and consists in forming the base of a metallic compound cast in a matrix, a part of the latter being formed by the plaster model of the mouth. The alloy used is composed chiefly of tin, silver and bismuth, with a small proportion of antimony.

Notwithstanding the above process was introduced and recommended to the profession under circumstances that promised to command a general recognition of its merits, yet such has been the pervading distrust of its fitness for the purpose under consideration, both in respect to the chemical properties of the alloy and its suitableness in other particulars as a base, that the method has never, at any time, been very generally adopted, and at present is only in limited use in the practice of those who were its earliest and most zealous advocates.

Method of Constructing Entire and Partial Dentures in a Base of Cheoplastic Metal.—In constructing entire dentures in a base of cheoplastic metal, an impression of the mouth is first secured either in wax or plaster. If an air chamber is to be formed in the plate, a cavity of the required depth and dimensions may be cut in the proper place in the impression. The latter is then varnished and surrounded with some plastic substance, as putty or clay, building it out on a level with the upper margin of the cup. The impression is then enclosed within a sheet-iron cup from one to two inches in depth, and sufficiently large to leave a space of a

fourth or half an inch between it and the borders of the impression, except at the heel of the cup, where it should extend posteriorly from an inch and a half to two inches, to form an articulating surface for the antagonizing portion of the model. The lower edge of the ring is imbedded somewhat in the putty to confine the plaster when poured into

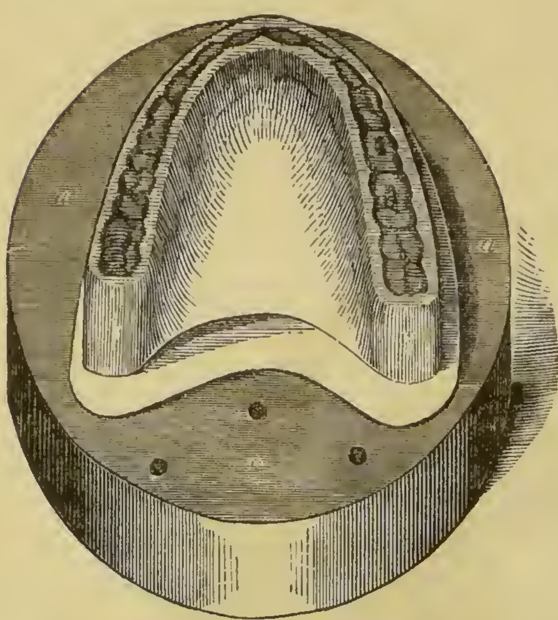
Fig. 117.



the former. The impression thus arranged preparatory to obtaining the model therefrom is shown in Fig. 117. The surface of the impression, putty and inside of the ring are now oiled, and the latter filled in with the plaster mixture for the model, the former consisting of equal parts by weight of plaster and finely pulverized felspar mixed with sufficient water to form a batter of the ordinary consistence. The model thus compounded will be found to be somewhat friable and will require careful manipulation in handling to prevent defacement of the surface. When the plaster is sufficiently hard, the ring and putty are removed and the model and impression carefully separated. The surface of the model

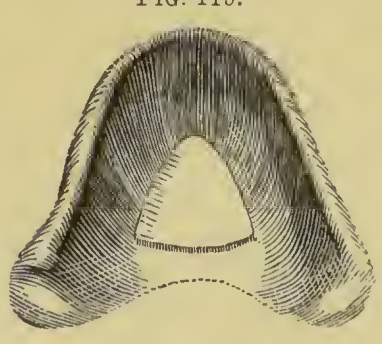
extending out from the sides of the ridge is now trimmed smooth and two or more conical-shaped holes formed in the surface posterior to the heel of the model; (Fig. 118,) when all parts of the model except the alveolar ridge and palatal arch are varnished. A temporary plate of thick tin-foil supported on the inside with a layer of wax, or a thin sheet of gutta-percha, is next accurately molded to that part of model to which the base is ultimately to be applied. A rim of softened wax of the proper width is then attached to the ridge of the plate when the latter is placed in the mouth and an impression of the ends of the opposing teeth secured in the usual manner. The plate and wax are then removed and re-applied to the model, (Fig. 118,) and the antagonizing portion obtained in the manner heretofore described.

Fig. 118.



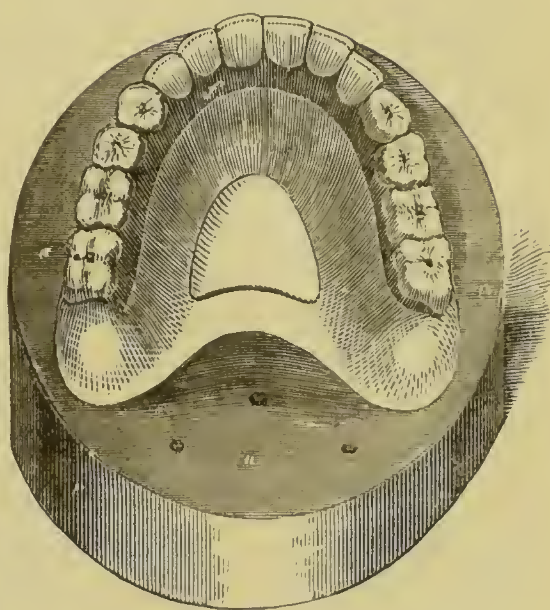
The two parts of the antagonizing model being separated, and the plate and wax removed, a second plate of tin-foil or gutta-percha is carefully molded to the face of the model (Fig. 119), to the border of which a rim of wax is attached as before, and having placed the plate in the mouth, the former is trimmed until the proper fullness and contour of the parts are restored; the plate is then removed and replaced upon the model. On this plate the teeth are arranged

Fig. 119.



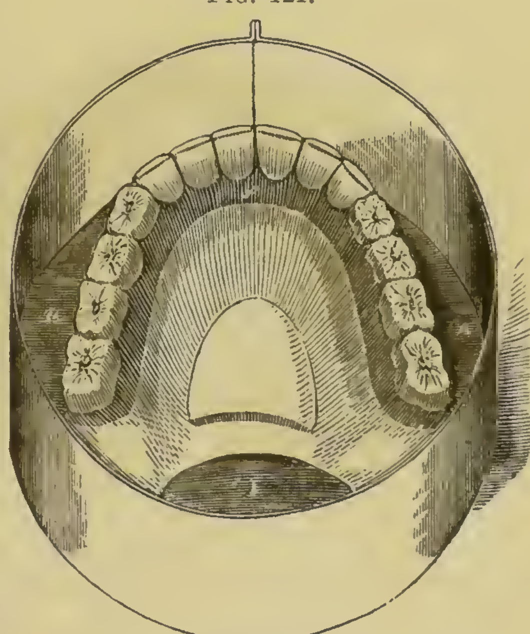
and are temporarily supported by the rim of wax, the latter serving also as a guide in respect to the fullness and particular outline to be given to the arch.

Fig. 120.



In the selection and arrangement of the teeth the same general principles should govern the operator as those that apply to other processes and which have already been fully stated in a former part of the work. It is not essential, however, in the present case, that the base of the teeth should be very accurately ground to the plate, as all interstices at such points will ultimately be filled in with metal; but where they unite with each other laterally, the coaptation should be as perfect as possible to prevent the intrusion of the fluid metal. The teeth manufactured expressly for this process have no pins, but are very securely attached to the base by means of grooves or dove-tails formed in their lingual surfaces, with sometimes holes running through the bodies of the bicuspids and molars and terminating in small depressions on their grinding surfaces.

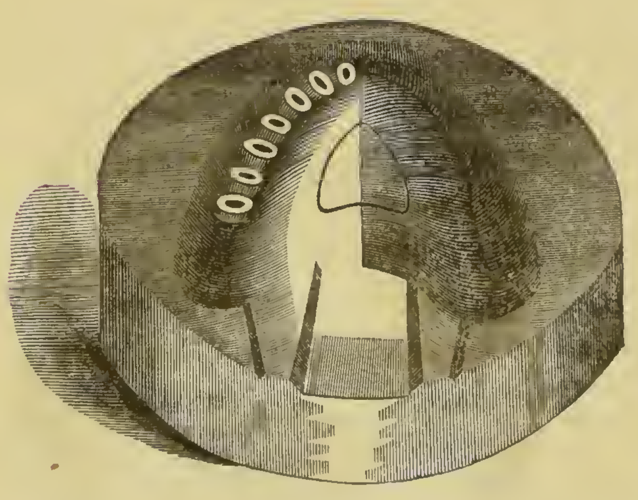
Fig. 121.



The teeth arranged, the wax supporting them on the inside is trimmed, and a rim of the same formed around the plate extremities of the teeth on the outside in the same manner as described when treating of the vulcanite base in the preceding chapter. The plate, with the teeth attached, is now pl ced upon the plaster model (Fig. 120), and the latter surrounded with a sheet-iron ring wide enough to extend half an inch or more above the points of the teeth (Fig. 121).

All exposed portions of the surface of the model, plate and wax are now oiled, and a batter of plaster and spar poured into the ring filling it even with the upper edge. When the plaster is sufficiently hard, the ring is removed, and the two parts of the matrix separated. All portions of the tin-foil or gutta-percha, and wax, are then thoroughly removed. A groove is then cut in the surface of that portion of the matrix containing the teeth, extending it from the centre of the posterior margin of the mold to the edge of the plaster, and also two small channels on each side (Fig. 122); into the former, the fluid metal is poured filling the matrix, and through the latter, the contained air is freely expelled as the former flows in.

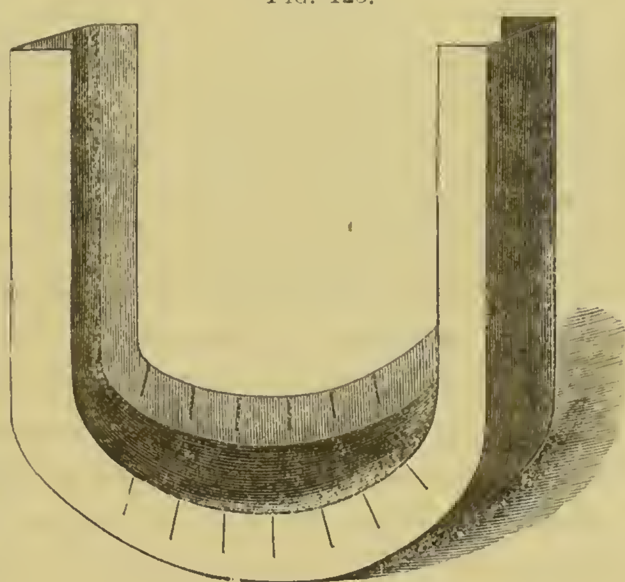
Fig. 122.



In the formation of a matrix for the inferior maxilla, the groove through which the metal passes to the mold should be extended through to the anterior part of the arch, entering the matrix at a point corresponding with the symphysis of the jaw; the vents, as in the case of the superior arch, extending back from each heel of the matrix. The surfaces of both parts of the matrix are then coated with a

carbonaceous deposit by holding them for a few minutes over the flame of a tallow candle, oil lamp or gas jet, when the two pieces are bound firmly together by wrapping them with wire. Before pouring the metal, the joint formed by the union of the two sections of the mold should be well luted, and to prevent still more effectually the liquid metal from escaping, the matrix may be encased in a sheet-iron box as represented in Fig. 123, the inside surface of which is first coated with a mixture of plaster and spar, and the matrix imbedded in it with the groove and vents upward. The mold thus prepared should then be thoroughly dried by exposing it to a heat of from 300° to 400° in a furnace, stove, or oven, or other suitable place, for five or six hours. It is then removed and supported in an upright position, and the melted alloy poured carefully but quickly into the matrix until full.

Fig. 123.



The manipulations concerned in the formation of entire dentures for the inferior maxilla differ from those described in connection with full arches above, only so far as the peculiar configuration of the under differs from that of the upper jaw, and which suggest no material modification of practice except as it relates to the provision made for the introduction of the fused metal into the matrix, the manner of forming the channel having been already adverted to.

In the construction of parts of sets of teeth in a base of the alloy under consideration, the same general plan is adopted

as described in connection with the use of vulcanizable gums, with such modifications only as are suggested by the nature of the material employed; a further description of the process, therefore, is deemed unnecessary.

Finishing.—The palatal face of the plate should be preserved in the condition in which it is first cast, as any filing or scraping of the surface will tend to impair its adaptation to the parts of the mouth to which it is applied, and to that extent affect its stability. The roughness of surface and all excess of metal around the borders of the teeth and on the lingual side of the plate are removed with suitably formed files and scrapers, and the use of these instruments should be continued until the plate at all points is reduced to the required form and thickness, when additional smoothness and uniformity are given to the surface by rubbing the latter thoroughly first with coarse and afterward with fine emery cloth. The piece is then washed in soap and water, when it is burnished and polished with a revolving brush at the lathe with chalk. The case is now put into a strong solution of caustic potash and boiled for a few minutes, when it is removed, again washed in water, dried, and repolished with chalk.

Repairing.—When it becomes necessary to replace one or more teeth that, from accident or other cause, have been broken or otherwise injured, the piece may be readily repaired in the following manner: First remove any remaining fragments of the tooth, and then file a groove in the base underneath; into the space thus formed, arrange properly the tooth of replacement, and fill into the groove with wax until the parts formerly occupied by the metal are fully restored. To the surface of the wax on the lingual side of the tooth a roll of wax, in the form of an elongated cone, is attached to the base, extending up half an inch above the summits of the teeth. The apex of the wax cone may be an eighth, and the base half an inch in diameter. To the surface of the wax on the opposite side of the tooth, another

smaller roll of wax is also attached, extending a like distance above the teeth. A sheet-iron ring, similar to the one used in forming the model, is now filled one-third full of a mixture of plaster and spar, of the ordinary consistence, and into this the plate is imbedded and the ring filled with plaster, the ends of the wax rolls extending a short distance above the surface of the former. The wax stems are now withdrawn, and remaining portions, encased in the plaster, melted by throwing the flame of a spirit lamp into the openings behind and in front of the tooth. The mold is then dried and heated, as in the first instance, and the melted metal poured into the opening in the plaster posterior to the tooth until it is seen to rise in the vent-hole in front. The plaster is then cut away, and the piece removed, and the added portions of the metal around the tooth dressed and finished in the ordinary manner.

CHAPTER XVII.

ALUMINIUM BASE.

Notwithstanding the comparatively recent date at which the metal aluminium first enlisted the attention of the profession as a base or support for artificial dentures, and the difficulties and discouragements attending the earlier experiments in its use, yet the successes which have been thus far attained stimulate to further and more extended trial of its fitness and capabilities, and afford a reasonable hope that it will ultimately be introduced into general practice. The information which the author has been able to obtain in reference to the working of this metal, either in the form of plate or by the process of casting, has been derived from a few members of the profession who have been more or less prominently identified with the process, and who have cordially and unreservedly communicated the results of their experience.

Aluminium Plate Base.—The aluminium plate is swaged and fitted to the mouth with metallic die and counter in the ordinary manner. Possessing, in its unalloyed state, about the pliancy of silver, it is comparatively easily swaged, during which process it should be frequently annealed.

When swaged, the succeeding steps in the operation, previous to arranging the teeth, are the same as those taken when gold or silver plate is employed. Rubber teeth in sectional blocks, single gum teeth, or plain teeth may be used, and these are attached to the plate either by the fusion of solder without the intervention of stays, or by lining up the teeth with strips of the same metal and soldering these

to the base as in gold work. If a rim is to be attached to the plate, it may be formed by soldering on a band, or from aluminium solder alone, after the teeth are temporarily arranged and tried in the mouth. The following simple but ingenious method of constructing a rim with solder is communicated by Dr. B. W. Franklin. When the teeth are arranged, if in sectional blocks, or ordinary single gum teeth, a plain, continuous rim of wax is formed along the labial borders of the plate, embracing enough of the gum extremities of the teeth to form a shallow socket or groove for the latter. If plain teeth are used, the wax rim is extended up between the necks of the teeth, giving it a festooned appearance. The teeth, and supporting wax on the inside are then carefully removed from the plate in such manner as not to disturb the wax rim, or in any way to mar or deform the wax sockets formed by the teeth. The inside wax and teeth being removed, the manner of proceeding is thus described by Dr. F.:—"I now invest the plate in a batter of equal parts plaster and asbestos, allowing the investment to come up against and flush with the edge of the wax or the shoulder caused by ends of section teeth, or matrices of the plain teeth, as the case may be. When the batter is set, carefully remove the wax; remove, also, any foreign substance from the space occupied by the wax.

"I now heat up the investment and plate to nearly a dark red heat, and with a blow-pipe and some iron instrument of convenient size and shape flow the solder. The solder is cut into squares $\frac{1}{6}$ of an inch thick by $\frac{1}{8}$ to $\frac{1}{4}$ long and wide; these pieces should be placed where wanted and heated up slowly (to prevent the tin from coming out in globules) until they begin to soften; then with the iron tickler and a gentle flame from the blow-pipe, agitate the pieces or move them along the surface of the plate, and perfect union takes place. Any amount of filling out may be done by adding pieces to surfaces once covered by the solder.

"When the rim is formed all around, the plate and invest-

ment may be placed in cold water and the investment removed, after which, with a brush and water, free the plate from all adhering foreign matter. If the soldering has been well and accurately done, there will be found, on replacing the teeth, a matrix for the ends of each gum tooth or sectional block, or for plain teeth, perfect sockets." The rim having been thus formed, the teeth are replaced upon the plate and supported by a narrow strip of wax, and the articulation, if necessary, revised or corrected. The piece is then encased in plaster and asbestos as when soldering ordinary gold work, and when brought to a red heat, the solder is carefully worked into the insterstices which present themselves on the lingual sides of the teeth, on to the plate, and well around the platina pins which should be headed. Dr. A. Starr recommends that the teeth and plate should be well cleansed and entirely free from wax or grease before soldering, and, where gas is used in the latter process, to avoid smoking the plate or solder. The same general directions already given apply to the method of soldering teeth to the plate supported by backings or stays. A continuous body of solder, as in the former mode, is doubtless the best and most durable, imparting greater strength to the piece.

Aluminium Solder.—The solder employed to unite the various parts of an aluminium plate is composed of this latter metal combined with tin.

The following formula is given by Dr. Starr, the process for forming which is covered by letters patent:

Aluminium,	7 parts.
Tin,	1 part.

The solder may be hardened somewhat by the addition of a small proportion of silver.

Plate or solder of this metal may be procured by first melting the aluminium in an iron ladle, and afterwards adding the silver and tin; agitate with an iron rod, pour into ingot molds, and roll out to the required thickness.

Cast Aluminium Base.—But little information is attain-

able in reference to the manner of casting aluminium plates except that imparted by descriptions explanatory of patented processes. Were it not for the shrinkage of this metal when cast, results very closely approximating accuracy might be obtained in its use by adopting the cheoplastic method of mounting teeth described in the preceding chapter. The method which has commanded most attention, designed to obviate this difficulty, is that practiced by Dr. James B. Bean, of Baltimore, to whom letters patent have been granted covering the right; first, on compensating for the shrinkage of the metal when cast; second, on apparata for casting; and third, on fastening the teeth to the plate.

The author is indebted to Dr. Bean for an elaborate monograph descriptive of his particular process. It is found impracticable to convey an intelligible comprehension of the manipulations involved by any mere abstract of the descriptions given, and a detailed account of the process, as given by the writer himself, is therefore introduced, believing that the recently awakened interest in this metal as a base for artificial teeth will justify the space devoted to its consideration.

It is to be apprehended that a process accompanied by such extended and tedious detail of manipulation, and the results of which are attained by such complications of expedients and apparata, will, from its want of ready adaptability to the exigencies of everyday practice, exclude it from general adoption. But it may, on the other hand, be reasonably anticipated that the same skill and patient experimentation which have achieved the results already obtained will yet devise more practical and less complex modes of rendering the extraordinary properties of aluminium more generally available for dental purposes.

Dr. Bean's Method.—*Taking the Impression.*—*Plaster of Paris* is the only substance we have yet found that can be relied upon for our purpose; and more particularly for alu-

minium work by this method, for we shall find use for its *expansibility* where *contractibility* would be a disadvantage.

A plaster impression may be taken in an ordinary impression cup, in the usual way; but the writer of this treatise has adopted, during the last ten years of his practice, a method of his own contrivance, and which he is now about to describe, that has been so universally successful in his hands that he is ready to pronounce it the best, and in the end the most economical method, because of such uniformly good results in all cases, with no after troubles.

First take a wax impression of the case in hand, from which get up a set of dies; by means of these a plate is swaged of sheet brass, about the thickness of an ordinary gold plate, covering that portion of the palate and alveolar ridge on which the plate to be made is designed to rest; and in partial cases, coming up on the buccal and labial gums between the remaining teeth. By careful adjustment to the model, or to the patient's mouth, this impression cup or *plate* is made so as to go to its place and come away easily; and the buccal edges are trimmed so as to allow an easy position of the muscles of the cheek. A piece of stout brass wire, about $\frac{1}{8}$ of an inch in diameter, is placed across the plate spanning the arch and resting on the alveolar ridge on each side, where it is secured by bits of silver solder. This serves as a handle for the cup, and is made the same way for a lower plate. The plate may be pickled and cleaned, after which it may be made as bright and beautiful as a gold plate, by dipping for an instant in pure nitrous acid, and again immediately in pure water. A slight coat of thin shellac varnish applied all over the surface of the plate while warm will prevent it from tasting of the brass while in the patient's mouth. This cup is now seized by the handle with a pair of forceps, and holding it over a gas or alcohol flame is coated all over the inner surfaces and edges with shellac, by rubbing with a stick of that gum—taking care not to burn the shellac by excessive heat. While the coating is yet melted, the plate is quickly

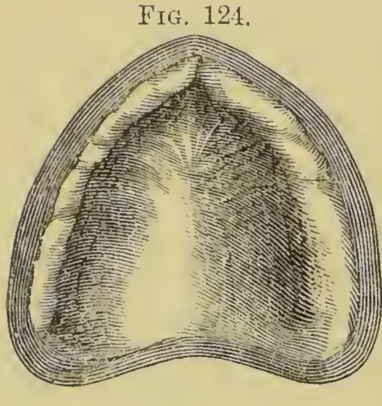
enveloped in a handful of cotton-wool, which is closely pressed upon the surface, and held in this position for a few moments, until it has cooled. The superfluous cotton is now picked off, the plate washed in pure water, and it is ready for the impression.

It is better to try the cup in the mouth that it may be seen that all is as it should be before proceeding. Then have ready a small goblet and silver spoon, together with sufficient of fine plaster and some powdered sulphate of potash. Mix the plaster with water to the proper consistency, add one or two grains of the sulphate of potash, and immediately commence stirring and applying it to the plate, so as to have it ready for the mouth by the time it begins to get thick by setting. A coating of $\frac{1}{8}$ of an inch thick all over the plate, with a little more piled up on the palatine surface, is quite enough, and it is now applied to the gums, with as much expedition as possible—pressing it to its proper place—and at the same time directing the patient to hold the tongue as still as possible, and breathe through the nostrils, in order to prevent the danger of nauseation. Also direct that the muscles of the cheeks be allowed to rest loosely and easily, so as to make their proper impressions. There is so little discomfort produced by this arrangement, that it can be left longer in the mouth than the ordinary impression cup, and the amount of plaster used is so small, that there is not that adhesion to the membrane produced by the absorptive power of so large a body of solidifying plaster as is ordinarily used. The impression may be readily removed by steadily pulling at the handle—using forceps if necessary—and at the same time lifting up the soft parts along the edges to allow the air to enter. A "scattering" partial case can thus be treated, so as to obtain an excellent impression, with but little trouble in bringing it away; and should any small portions of importance break away, they are almost always held safely attached by the cotton fibre, and can be safely returned to their place. The impression, now cleared of any useless frag-

ments and debris of plaster, is dried by a gentle heat, if necessary, and varnished with two or more coats of clear shellac varnish. Any imperfections in the impression are repaired with hot wax, applied with a small wax tool; and in partial sets, vacancies occupied by the natural teeth are filled up with bits of sheet wax so as to make the outer edge even.

A *rim* of wax is now placed all around the impression, by taking a strip of sheet wax, about $\frac{1}{8}$ of an inch wide, gently warming it and bending and pressing it with the fingers until it is neatly fixed around the edge as represented in the cut, Fig. 124. The sheets of wax prepared by S. S. White for vulcanite base-plates answers admirably for this purpose. Gently warm the sheet, cut off strips with scissors and attach them as described, using a hot wax-tool, as a tinner would a soldering-iron, for securing them in place. In the case of a lower impression, the space between the two sides should be filled up with a sheet of wax, of proper size and shape, secured along the edges as was the "*rim*."

FIG. 124.



Making the Plaster Model.—The next important step in our undertaking is making the model, which should be an exact fac-simile of the parts on which the artificial plate is to rest. The impression, already prepared for casting the model, is now soaked in water until thoroughly saturated; and to prevent injury by a gradual solution of the plaster, this water should previously be made a saturated solution of plaster, by stirring a small portion of fine plaster into it and allowing it to settle, when the clear portion is poured off for future use. In all cases of making a plaster cast or mold on a plaster model or impression, the latter should always be thoroughly soaked in this saturated solution of plaster, which we will hereafter designate as "*plaster water.*"

A couple of hog-hair brushes such as are used by artists

should also be provided—one for oil and one for plaster. It is also very desirable to have a sable hair pencil, for working plaster into minute crevices of a mold or impression—these are far better than feathers for this purpose, and if always washed before the plaster sets will last a long time. To give an idea of the proper size, Fig. 125 represents the length and thickness best adapted to the purpose; the larger one representing the hog-hair brush, and the smaller one the sable-hair pencil. Two or three of each kind should be at hand.

FIG. 125.

The plaster impression, now removed from the water, is wiped dry with a soft napkin, or tissue paper, and carefully oiled all over the surface with pure olive oil, by means of the brush just described. The best plaster manipulators prepare their plaster batter by sprinkling the dry plaster into a sufficient quantity of water, until the water is all soaked up, and the plaster is all wetted, before stirring it. The stirring should then be gently done, without entrapping any air-bubbles, until almost ready to thicken, when if too thick for use, a little water is added. A portion is now taken up by the brush, and applied to the deepest parts of the impression first; then to the entire surface, adding more and applying it almost as one would paint on such a surface. As soon as the surface is covered, and the impression filled up, the remaining plaster is piled up on the centre until sufficient in quantity for the model, and holding the cup by the handle, the plastic material is fashioned by the spatula into the required form, the wax rim being the guide for the size and shape.

Where the gums are hard and unyielding, and it is desired to make a plate to fit easily upon them, the plaster for the *model* and the *mold* should be mixed *thin*, in order to secure as much expansion as possible. But if the gums are soft and spongy, and it is desirable to have a *close fit*, then this may be secured by mixing all the plaster *thick*—for it has been found that plaster mixed *thin* expands more in setting than

that which is mixed *thick*. There is also great difference in the expansion of different specimens of plaster—the quick-setting expanding most.

If the palatine arch is a very *deep* one, it will be necessary to make the *model* in *two pieces*, or the palatine portion of the *mold* in *three pieces*, in order to allow the removal of the middle piece of the mold from the model, and favor the expansion of the plaster. We will here describe the first of these plans, the other will be described under "*Constructing the Mold in Parts*." To secure a division in the model itself, the best plan is to set up in the impression a septum of thin sheet lead, forming a vertical plane in the median line of the palate, and fitted somewhat to the inequalities of the impression. This plate should have two or three small projections struck up on one side, by means of a small conical punch, and the opposite side has some cotton fibre attached with shellac, in the manner described for preparing impression cups. This plate will present something of the shape shown in Fig. 126, which is one-half the size, and represents the side on which are the projections described. Its proper position will be readily understood when applied to an impression of one of those deep palates now under consideration. The side having the projections is oiled, the cotton on the other side wet with water, and while filling up the impression, this plate is set up in the middle, along the median line, so that when the model is trimmed to proper size and shape, it may be carefully broken apart and placed together again, in the same position. If the foregoing method of dividing the model has been neglected, or is considered too tedious, the object may be accomplished by sawing half through the model from the back, and breaking it apart.

Fig. 126.

In removing the impression from the model (which should be done soon after it has hardened), the wax rim is first pulled away from around it, then the surplus plaster of the

impression cut away from the edges, so as to free every portion of the edge of the brass cup; then, heating it over a lamp flame until the shellac is softened, the cup may be removed by the careful introduction of a thin instrument at the edge between the plate and plaster—sometimes bringing away a portion of the impression. Those portions of the impression which remain should be lightly struck all over the surface by the gentle taps of a small hammer or such like, and again heated over the lamp flame, directed if necessary by the blow-pipe, by which means the remainder is easily detached. The model is now trimmed to the proper size and shape desired for the matrix, and this should be such that the thinnest part of the palatine portion, where the posterior edge of the plate is to come, should not be less than one-half inch, or more than five-eighths of an inch in thickness, so as to accommodate itself to the position of the *gate*, when inserted in the flask. The model should also be made smooth and level on the back portion, and now, if there is a septum in the model, it should be broken apart—taking great care not to injure the edges of the fracture—and in this case, let the two portions dry separately, when they may be fastened together by a little melted wax.

The foregoing directions, with modifications which will be evident to the dentist, will serve equally well for taking an impression and making a model for a lower set.

After drying, the model is carefully varnished with two or three coats of shellac varnish, and any faults or imperfections of the surface should be repaired with wax. If there is to be a chamber, this should now also be provided for.

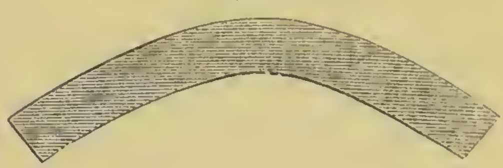
The writer is decidedly in favor of shallow chambers, and some of our best operators are recommending *none at all.* If this principle holds good in other kinds of work, it is far more advisable in *aluminium,* on account of the superior fit. The principal advantage of a chamber in a "permanent set" is in easily securing a firm adhesion *at first,* consequently giving to the patient satisfaction at once. But for tempo-

rary sets, the piece is undoubtedly very often held firmly by the chamber, long after an amount of absorption has taken place in the alveolus that would entirely prevent the plate from being sustained without a chamber. When an air-chamber then, must be used, we take a piece of sheet lead, which should seldom be thicker than one-fortieth of an inch, or about No. 23 or 24 of Stubbs' gauge. This is cut to proper size and shape, and is easily pressed into its place on the model by the fingers, aided by a blunt pointed burnisher. A hole is made through the palatine portion of the model, about the centre of the space occupied by the chamber-piece. By means of this hole, it is easy to secure the chamber-piece in place, by introducing into it, from the back, a small quantity of hot wax; and it is also useful in removing the middle portion of the mold from the model, as will be seen hereafter. Where the model is made in two pieces, the hole through it is hardly necessary, and the chamber-piece may be simply secured by a little wax.

Constructing the Mold in Parts.—The model properly prepared, smoothed and leveled on the back, soaked to saturation and oiled over its varnished surface, is now placed back downward upon a piece of plate glass, or other perfectly level surface, and with a roll of pipe-clay, potters' clay or other similar substance, a barrier is formed, commencing at the median line in front, forming a vertical wall a little to the left of it, up to the summit of the alveolar ridge, or highest part of the model; then along this ridge, on the right hand side, a little to the inside of the summit, (so as to leave room for trimming,) then down to the glass again at the posterior right hand corner of the model. We now have fenced off as it were by a wall of clay, that portion of the model on which we propose to form the first of the four or six parts of the mold; and as it is designed only to prevent the plaster from running over other portions of the model, it is not requisite that it should be very carefully done, as the piece to be cast is so easily trimmed to proper shape. It may be

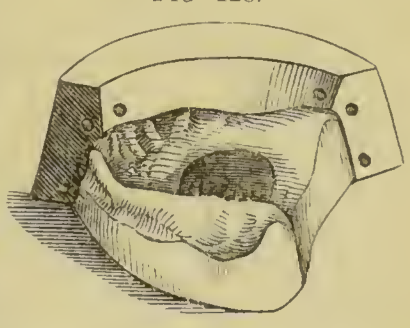
necessary now to again go over that part of the model with the oil brush on which the plaster is to be cast, and to clear away any particles of clay, etc., that may be along the base of the wall. The plaster being mixed as described for making the model, the first portions are applied over the surface by means of the brush, and the remainder added as it begins to set; while by means of the spatula, etc., it is built up into the required shape, giving the plaster about half an inch of thickness in all its parts, measured from the surface of the model. There is some advantage in having a strip of sheet lead with which to surround the model, after the first portions of plaster are applied, for the purpose of retaining the subsequent additions, and giving the proper shape. This strip should be about one inch and a quarter wide, and six or eight inches in length, cut in the form represented in Fig. 127. This leaden band may be bent and adjusted so as to regulate the size, shape and thickness of the side pieces of any mold.

FIG. 127.



As soon as the plaster has become sufficiently hard to bear trimming, the clay wall is removed, the piece separated from the model, and carefully trimmed, so that the line of division may begin exactly at the median line or frænum, in front, and make a sharp edge along the highest portion of the ridge, and so as to form a mitre joint at the corner, with the posterior piece, which is made last. When trimmed and again placed upon the model, it will present the appearance clearly shown half size in Fig. 128. The six small conical cavities, in the position represented, are formed by means of a spear-pointed drill—they should be one-sixteenth to one-tenth of an inch deep, and made near the edge next the model

FIG 128.

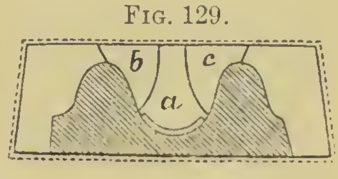


as represented in the cut. The surfaces of the piece in which the conical holes are made, and which are to form joinings with the other portions, are now varnished with two coats of shellac varnish, then soaked in the plaster water, placed firmly upon the model on the plate of glass and secured in two or three places around the edge by hot wax. We now build up the wall of clay, as before on the other side—except that the piece already made forms the first portion at the median line in front. The strip of lead, if used, may now be placed in position, and this side in like manner cast, trimmed, drilled with the spear-pointed instrument as before, and varnished on the surfaces that are to join the remaining pieces. The model and the two pieces are again saturated with the plaster-water, the two pieces are placed in their proper position on the model, where they may be secured by passing around them an elastic rubber band. Such bands as are sold by the stationers, for holding loose papers, etc., are admirably adapted for this purpose.

A wall of clay may now be built up at the posterior portion of the model, and if the palatine vault is shallow and flat, the middle or palatine portion of the mold may be cast in one piece, observing the precautions and directions previously laid down, as also those following in regard to the care of the chamber, etc. But if the palatine vault is a deep one, the middle piece of the mold would be wedged fast by its expansion, unless the model has been prepared in two pieces by means of the leaden septum before described; in which case, we proceed just as in a shallow palate, making this middle portion in one piece, and when this is set, the two side pieces are first removed, then the model is removed from this middle portion, one side at a time. Yet it may sometimes happen, that in a deep palate, or a lower set, where the model is in one piece, and it is impracticable to divide it properly; in such a case this palatine portion must be made in three pieces, as follows: Clay is built up against each side-piece of the mold already made, and on the model, leaving a vacant

space between, in which must be included the entire air-chamber piece, (if there is one,) and not come nearer to its lateral edges than one-sixteenth of an inch, and in a lower case should occupy the middle third of the space between the alveolar ridges. This middle piece is bounded on its anterior portion by the two pieces already made, on each side by the clay, and the plaster being applied as before directed, may be built up at the posterior portion by the spatula. As soon as the plaster has hardened, the rubber band is removed, the two side pieces and the clay are taken away, and by introducing a blunt pointed stick of wood through the hole in the back of the model, this middle piece may be pushed away from the model, together with the chamber-piece, which is carefully removed from its place, without injuring the delicate edges of the chamber formed by it, as this is important. This piece is now trimmed on the sides, so as to form a clear sharp edge, with nearly a right angle, where it rests on the model. Avoid trimming so near the chamber as to endanger the breaking away of its edges. The small conical cavities, as before directed, are made in the surfaces which are to join the side pieces of this palatine portion, and these surfaces are also varnished. All are again soaked in the plaster water, the three pieces placed upon the model, (leaving out the chamber piece,) and the rubber band passed around as before. The two vacant spaces on each side of the middle piece are now to be oiled and filled with plaster, one at a time. The first one being filled, and the plaster having become hardened, it is taken away and removed from the middle piece; this middle piece again replaced on the model, as before, and the other side cast, as was the first. The shape and position of these three palatine pieces may be clearly seen in Fig. 129; *a* is the middle piece, resting on the chamber; *b* and *c* are the lateral pieces of the palatine portion, which join the large side-pieces first made, on the summit of the alveolar ridge. If the

Fig. 129.



sides of the middle piece *a* were trimmed straight up from the model, in place of the shape represented in Fig. 129, the edges *b* and *c* next to it, would be exceedingly thin and frail, and very liable to injury.

The posterior portion of these three palatine pieces being each properly trimmed, drilled, varnished, etc., they are all soaked, and again placed upon the model; this time putting on the rubber band in another position, so as to hold all together, as represented in Fig. 129, where the rubber ring is represented by the dotted line.

It should here be remarked, that in deep palates, where the palatine portion of the mold can be made in one piece, by the separation of the model into two parts, as before described, we gain some advantage in time and in the simplification of the mold. We also avoid the marks on the matrix caused by the seams of the palatine portion when in three parts. When practicable, therefore, it is decidedly the best plan to make the palatine portion in one piece.

The posterior piece is formed in the same manner as the others; it may be built up entirely with the spatula, or molded by means of the leaden band, as were the side pieces. The whole is now trimmed to proper shape on the outside,

FIG. 130.

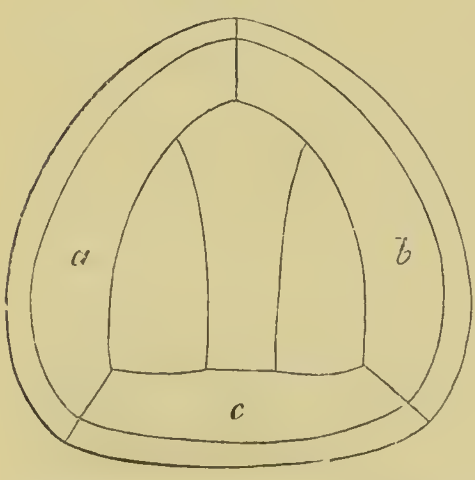
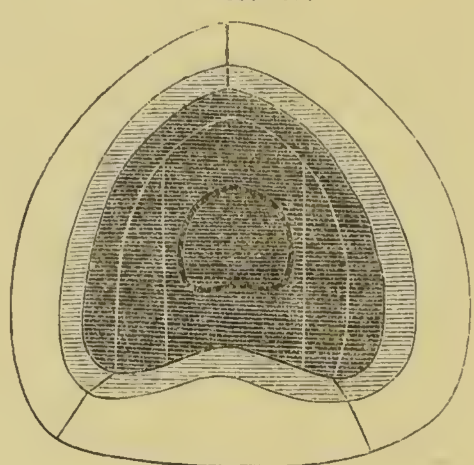


FIG. 131.



when it will present something of the appearance figured half size in the diagrams, Figs. 130 and 131. Fig. 130 re-

presents the exterior of the mold, showing the back portion, which exhibits the joinings of the two side pieces *a* and *b* with each other, and with the posterior piece *c*—these three enclosing the palatine portion—in one piece, or in three, as represented. Fig. 131 represents the interior of the mold, showing the position of the chamber and the interior joinings of the parts.

The mold being partially dried, each piece is carefully varnished on that portion forming a part of the inner surface of the mold. Two coats of clear shellac varnish should be applied, but if any portion of the surface looks "dead" or destitute of gloss, these parts are again brushed over with varnish until they dry with a glossy appearance.

All the parts of the mold are now placed properly together and secured by the rubber band, when it will be found, that the expansion of all the parts, as made in the order directed, will have caused a slight opening in front between the two side pieces—this should be left open, or closed, as the case is desired to fit loosely or closely on the buccal surface of the alveolar ridge—for we here have some additional control over the fit. It may be closed by the force of the rubber band, or may be kept open by inserting a small bit of card of proper thickness. Where the card is inserted, it should be done before the last piece of the mold is made.

Any imperfections along the joinings of the parts, or other portions of the mold, are now repaired with wax, and additional varnish applied to any portions that may require it. The whole is soaked to saturation in plaster water, and it is ready for casting the matrix.

Casting the Matrix.—The matrix is composed of plaster of Paris and pumice-stone, in powder, in the proportion of one part of the former to two of the latter. The plaster should be of the best quality and very fine; the pumice should be of a certain size, and that which is found to answer best for the purpose is known in commerce as No. 3. It

can be procured of the proper size and kind from those who deal in such goods, and is now kept at some of the dental depots. If it cannot be procured of the requisite grade of fineness, the ordinary powdered pumice can be employed, provided it has enough of the coarse in it, or it may be made by pulverizing the stone. It should first be sifted through a brass wire sieve, of about 45 meshes to the inch, and then the finest portions sifted out by a sieve of No. 10 bolting cloth. What is left behind is of the proper size to produce the requisite porosity for the gases formed to pass through the mass. If it were much finer, the composition would be too compact, and would "blow" as the molders say, and produce bad castings; coarser than this would produce a roughness on the surface of the castings.

The mold having been removed from the plaster-water in which it was placed to soak, is now oiled and placed over a small heating flame so as to become slightly warm, while the pumice composition is being prepared. *One ounce* of powdered pumice is weighed, and placed in a shallow pan, where it is boiled for a moment with water, in order to expel the the air from its minute pores; after which it is transferred to the cup in which the composition is to be mixed, left to settle for a moment, the water poured off and *one-half ounce* of plaster added and thoroughly mixed. Water is added sufficient to make it the consistency of cream. This composition should be apparently much thinner than plaster is ordinarily used, and should be poured into the mold before it begins to set. If mixed thick, or stirred after it has began to set, the particles do not have an opportunity to arrange themselves in compact order in the mold. But when of the proper consistency, the particles settle down through the water, and in combination with the plaster, *stratify*, into a more solid mass, and the extra water runs off at the top.

As soon as the composition is sufficiently mixed, a small

portion is poured into the mold and spread over the surface with the brush, then the rest added, until the mold is full. As the composition settles to the bottom, other portions are added, and if there is much undercut, the brush is gently pushed in around the edge of the alveolus where the undercut may be, so as to fill out the cast, as there is liability to a fault at that point. When the last portions have been added, the water has drained off, and the composition has began to thicken, it is smoothed off even with the top of the mold, and left to set. If it be kept gently warm, the composition sets quicker and more effectually, and expands more.

In twenty minutes, or half an hour, the cast is sufficiently hard to remove from the mold, and it comes away easier at that time, than if left longer. The rubber band is removed, and by inserting an instrument at the corners, each piece of the outside portion may be slightly started, then carefully removed, one at a time. If the palatine portion of the mold should still adhere, a little water applied around the edge, and a gentle, steady pulling by the front portion, will bring it away safely, and we have left a beautiful smooth cast, which is to serve as the matrix on which to cast the plate. As this cast is very tender and fragile, it should be handled with care.

Constructing the Model Set.—*The Model Base-Plate.*— This should be formed on a plaster model, cast into the mold in parts, as before described in casting the matrix; using however pure plaster, as in casting the *original model*, in the impression. This we will call the *false model*, and being expanded as is the matrix, a base-plate formed upon it will more readily fit the matrix, and consequently injure it less than if formed on the original model. A thin sheet of tin foil is molded upon the false model just described, and on this is molded by means of the fingers a thin sheet of yellow wax, about the thickness of an ordinary gold or silver plate for an upper set. Again upon this sheet of wax is molded a sheet of druggists' thick tin foil, such as is furnished by the dental

depots, and with a round pointed burnisher this is made smooth, even and well down on the model, taking care not to press upon the prominent parts so as to make the wax plate too thin at those points. If the plate is not yet thick enough, another sheet of the thick tin foil is molded upon the last one, then removed, and holding it over the lamp flame, the side which is to go next the plate is coated with wax, when it will readily adhere, and may be burnished down as before. The plate thus prepared should not be more than twice the thickness of an ordinary gold or silver plate for an upper set. It should be neatly trimmed to proper dimensions by means of a sharp knife slightly warmed, again placed upon the model and the edges pressed down.

This plan furnishes a base-plate of even thickness, and of sufficient strength and rigidity even for taking a bite, if carefully managed, but in most cases it is much better to form another of gutta-percha or wax, over the same model, for the purpose of taking the bite.

Taking the Bite.—This may be done by any of the ordinary methods used by dentists for gold or vulcanite work, using the gutta-percha plate just described in the usual way. Almost every practitioner has his own peculiar style of articulator. Some of the brass articulators now gotten up and for sale at the dental depots are very convenient, and very perfect in their operation. That described as articulator No. 2, in S. S. White's dental catalogue for 1867, page 176, is one of the best. No. 3 also has some desirable advantages. The writer, however, uses for all cases of entire upper or lower sets, the *Condylometer* and *Maxillary Articulator* invented by him for the construction of his *Interdental Splint*, used in the treatment of fractured jaws. The apparatus is briefly described in *Harris' Dictionary of Dental Surgery*, third edition, under "FRACTURES *of the Maxillary Bones.*" The writer regrets that the want of space will not allow a detailed description here. The *condylometer* is an instrument for measuring the relative position of the "hinge-joint" of

the jaw of any patient; and from this the articulator is set, and the "bite" arranged in it, so as to be an exact representation of the proportions and mechanical movements of the jaw of that particular patient. Therefore, any alteration can be made in the *length* of the "bite" without the slightest danger of destroying the correctness of the articulation. And this is an important desideratum in almost every case. Ordinarily, the simplest and easiest method of constructing the articulating model is to place the "bite" taken with the gutta-percha plate upon the *false model*, then secure this to the upper portion of one of the brass articulators before mentioned, by means of plaster; then form the lower jaw of plaster in the impressions of the lower teeth, or if there is a lower set, in the lower base-plate; or the lower false model may be fixed in the lower plate of the articulator. When the wax plates, etc., are removed, the tin pattern plate or plates are placed in their proper position, secured by a little wax, and the articulating model is complete, if the "bite" is correct. If the two jaws are not far enough apart, they may be set to the proper distance, and the vacancy under the palate of the upper plate filled with plaster; or if too far apart, the plaster is trimmed away, the jaws set to proper distance and vacancy filled as before.

Grinding and Adjusting the Teeth.—A roll of wax is placed along the alveolar ridge, against which to rest the backs of the teeth or blocks, in their arrangement in the articulator. Those who are skilled in grinding teeth will need no other directions than for vulcanite, except in the slight alteration of the blocks. If the blocks have a thin edge, not covered with gum color, as formerly made for vulcanite, this must be ground away, so as to leave an even square edge along the whole line of the gums; and this should be a graceful curve, in a full set, as it is to form the line of union between the metal and the porcelain gums. In any case of using the blocks or teeth as at present made, this edge of the gum portion must be ground square and even as described,

except as in partial cases, where the artificial gum is ground and fitted directly upon the natural gum without any metal back of it. As the blocks are ground and properly fitted, another slight alteration is made by grinding out a small nick or depression on the inner side of the joint, and in a line with the pins. This should be done with a small corundum wheel, not over an inch in diameter. It is designed to admit between the teeth or blocks a septum of aluminium, cast upon the plate, through which a hole is afterwards drilled, and by means of which, and the headed platinum pins, the teeth are firmly locked to the plate, as will hereafter be described. Fig. 132 represents the depression or "nick" ground out near the pin, as also the square edge of the gum ground off as described. These alterations will doubtless be made by the manufacturers, as soon as the work is sufficiently introduced to demand an alteration of their molds.

Fig. 132.

The teeth having been satisfactorily arranged in the articulator, are secured to the base-plate by means of melted wax, which should only be applied along the outer margin of the blocks. The teeth or blocks are now carefully removed, one by one, so that they may again be replaced with certainty; and it is better that they be boiled in water, and wiped dry while warm, so as to remove all wax and dirt, and they are ready for

Investing the Pins in Plaster.—The teeth or blocks are placed on a level surface, with their pins pointing upward, and with some fine plaster carefully mixed and applied by means of the brush before described, the platinum pins are completely enveloped in the plaster, adding as it begins to set, a sufficient quantity to allow of it being afterwards trimmed, so as to form a continuous ridge along the line of the pins. This ridge is then notched between the pins in the two front blocks, as represented in Fig. 133, which is a view showing the upper edge of the gum, and

Fig. 133.

giving a very clear idea of the plaster investment of the pins, and also of the "nicks" or depressions at each end of the block. In the molar blocks it is unnecessary to notch between the pins, as the septums between the blocks will be sufficient. The trimming of this plaster investment of the pins should be done with care, and always with reference to the plaster remaining fast on the pins, and drawing easily away from the wax. And it is well here to remark that teeth with large headed pins, as those patented by S. S. White, are far the most desirable for this work.

When the plaster investments of the pins have thoroughly dried, they are coated with shellac varnish, and the teeth or blocks smeared all over with olive oil, to prevent the wax from adhering when used in modeling the base.

Modeling the Wax.—The roll of wax first placed upon the alveolar ridge is now removed, and the teeth again adjusted to the model plate in the articulator; and when all is satisfactory, we take a suitable wax tool, and upon it melt a small portion of pure yellow wax, holding it over the lamp or gas flame until it begins to smoke; this drop of wax is now introduced behind the blocks, between them and the plate, and being so hot it quickly flows into the most minute portions of the vacant space between the blocks and the plate. This operation is repeated, with fresh portions of wax, until the whole vacant space between the blocks and plate is completely filled. It is important that there should be no vacant spaces or air-bubbles under the blocks, for these, being reproduced in the metal plate, will be filled up with the solder composition, and consequently will add unnecessarily to the weight of the piece. When the teeth come away from the wax model-plate, they should leave an accurate impression of themselves in the wax.

The teeth being fastened to the plate in proper position, the lower portion of the articulator may now be removed, in order to facilitate further operations. The modeling of the wax is now to be completed, building up to, and over the

plaster investment of the pins, so as to completely cover them with a sufficient thickness of wax, shaping and smoothing it around the necks and edges of the teeth exactly as it is desired to be in the aluminium plate. And here the operator who has been accustomed to vulcanite work should be reminded that he must lay aside all of his *vulcanite ideas* about modeling the wax; for the material he is now going to deal with is quite different from that compound of vegetable gum, sulphur, and mercury, which can be scraped and filed almost as easily as wood. The metal aluminium, of which the plate is to be cast, we may safely say is *five times* as strong as an equal thickness of rubber, and can be cast, by means of the apparatus invented by the writer, in plates as thin as those ordinarily used for gold or silver work, and faithfully representing every minute part of the wax model, including all marks, scratches, or imperfections, that may have been made upon it. Therefore, it is important and necessary that great care should be taken in producing in the wax model all the fullness and proper form desired in the plates, and no more, particularly on the inside or palatine portion of the model plate, and along the edges of the blocks; so that there will be need of but little filing or scraping on this portion of the work after the plate is cast. The pins must be covered sufficiently, but not a drop more wax should be added along the backings than is necessary to cover the pins and give the requisite strength; and this will be far short of what is usually employed for vulcanite.

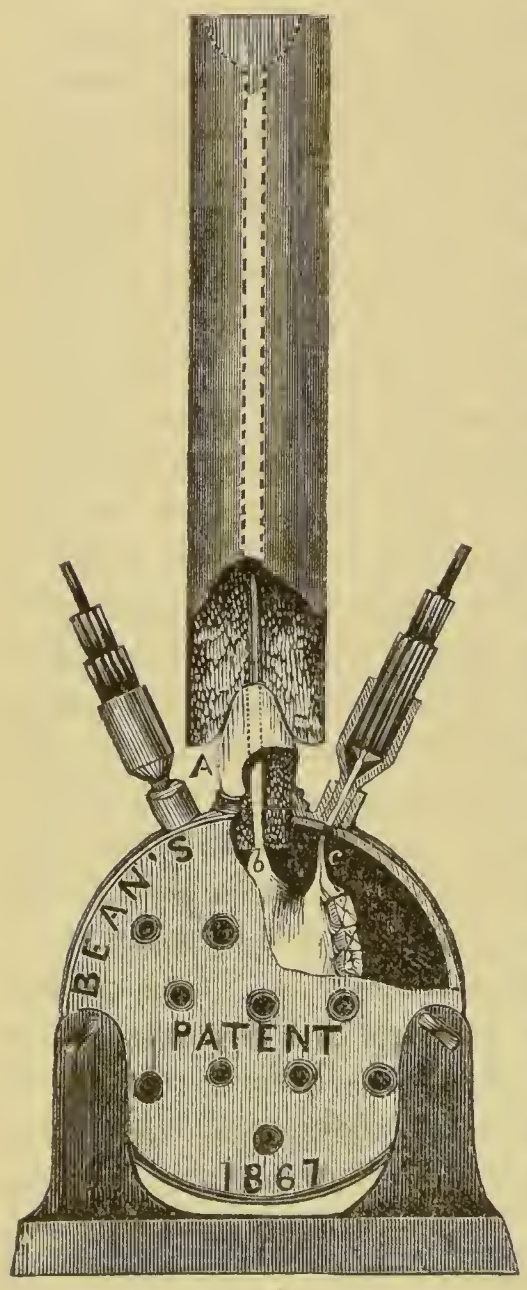
When the wax is satisfactory as to its form and quantity, we take a small blow-pipe, and a small alcohol or gas flame, and quickly dart the flame upon the wax by gentle puffs, going over the surface of the work until all is completely polished, as it will be if this operation is skillfully done, taking care not to heat it enough to make the wax run. The case may now be tried in the patient's mouth, if necessary, but great care is required to prevent disturbing the teeth, as they are very slightly held by the wax.

The teeth can now be easily removed from the wax, if the plaster has been properly trimmed and oiled. If the curvature of the upper edges of the gums is not satisfactory, this may be corrected by grinding, placing the blocks back in their impressions as this is accomplished. Then after oiling the portions ground, the wax is again remodeled along these to correspond. The model set, now complete, is removed from the false model, slightly warmed, and placed upon the *matrix* already described, which should be wet, to prevent the wax used in fastening the plate from being absorbed by it. The edges are carefully attached all around, as is the usual practice in vulcanite work, so that the plaster cannot run under them. The whole plate and teeth are now covered with a coat of oil, and the piece is ready for investment in the flask.

INVESTMENT IN THE FLASK AND COMPLETION OF THE MOLD.—*Selecting Flask and Conduit.*—The *flask* intended to be used should first be selected, and see that its guide-pins are properly adjusted so as to go together and come apart easily, and yet hold the two sides in permanent relation to each other. The joinings of the two halves of the flask should also be so smoothed and leveled as to form a close-fitting joint all around. The fitting is generally sufficiently well done by the manufacturer, but should always be looked to in a new flask. The clay *gate* should next be selected, and see that it fits properly the opening in the flask. This opening is reamed out so as to fit the tapering gate, but sometimes the irregular shrinkage of the clay in burning renders it necessary to make some additional adjustment. The gate should now be fitted to one end of the long fire-clay *conduit*, by grinding them together. The pointed end of the gate will fit either end of the conduit, but owing to the contortions before mentioned, caused in the manufacture, there is generally a choice in selecting the best fitting end. The grinding should be done dry, and the dust formed should be very frequently blown away, as the parts are worn by the friction. A good plan is to plug up the larger end of the gate by a

ball of wax, and to blow through the conduit all the time while grinding them together, until the joint is sufficiently perfect. The gate, and end of the conduit into which it has been fitted, should be marked with the number stamped on the flask, or in any other way, so that it may be readily put in proper position when going to cast the piece. The gate should also have a shallow notch filed about half an inch from its larger end, and extending at least half around it; in this notch is secured a piece of soft binding wire, which is wrapped around it, and twisted into a knot, leaving an inch or so of the free ends for forming into loops. By means of this wire the gate is secured from dropping out of its place in the lower portion of the flask, after the case is invested. Fig. 134 represents the different parts of the apparatus in position, portions of one side being broken away to show sections of the interior. The flask is clamped in the stand or holder by means of the set-screws on each side. A is the gate passing through the opening in the flask, and connecting with the model plate at *b*. The conduit, as is represented, rests on the pointed end of the gate, and on each side of the

FIG. 134.



gate are the vents, with their bundles of wires or small rods, and connecting with the interior of the mold by "leaders," as at *c*.

Investing in the Lower Portion of the Flask.—The case being now already attached to the matrix, and ready for investment, is placed in a saucer, or shallow cup, containing plaster water, until it is thoroughly wet. One ounce of pumice is thoroughly wetted with water, and to it is added one-half ounce of dry plaster; these are mixed to the consistency of cream, or even thinner—same as directed for casting the matrix, except that the pumice is not boiled. A small portion of the composition is now placed in the bottom of the lower half of the flask, while resting on a level surface, and the matrix bearing the model set of teeth is placed in its proper position in the flask; the clay gate, with its binding wire attached, having been wetted, and having a plug of wax closing the end that is to go inside the flask, as at *b*, Fig. 134, the loops of the binding wire are imbedded in the now liquid composition. The ring, or upper portion of the flask, is now placed firmly down in its proper position, and the gate pressed well up into its place, so as to remain firm, but not so as to separate in the least the two portions of the flask. The remainder of the plaster and pumice is now poured in around the sides, until the flask is filled up to the joining. After the composition has began to thicken, the part which has run into the palatine portion of the plate can be removed, or pushed out upon the sides, by means of the brush, and by the time it is quite stiff this may be made all clear and smooth. The ring, or upper portion of the flask is now removed, and with the spatula, brush, or other suitable implement, the yet plastic composition is leveled and smoothed all around the model set and gate, until satisfactory. In all cases, it is preferable that the teeth should be entirely above the line of division of the flask, but this line should be but little below the edge of the wax rim, where it joins the teeth or gums. As soon as this investment has completely set, and

before it has dried, the whole surface of the composition around the model, as well as the gate, where a parting is to be formed, is covered with a coat of shellac varnish, flowed on from a soft brush, with as little rubbing as possible, and when dry another coat is applied. After opening the flask, it is desirable to get rid of this coat of varnish, which can be easily done by peeling it off as soon as the flask is opened; but if the composition to which the varnish is applied be dry, the varnish takes such hold that it is impossible to remove the film afterwards.

The "*leader*," as the founders call it, from the gate to the plate to be cast, is now provided for, by placing a thick piece of sheet wax from three-eighths to three-fourths of an inch wide, leading from the gate to the posterior portion of the plate—commencing with the diameter of the opening through the gate, and spreading out so as to make a free communication with the plate, as represented at *b*, in Fig. 134. This "leader" being trimmed and smoothed as desired, by the hot wax-tool, the ring or upper portion of the flask is again placed in position, and the vents also inserted in their places on each side of the gate. Two small cylinders of wax, about one-tenth of an inch in diameter, are provided, one end of each is inserted into the open end of the vents, on the inside of the flask, and lead toward the nearest point of the model plate, where the end is pressed down and securely fastened by melted wax. The other ends next the vents, are also secured in place by melted wax, but so as to allow the vents to come away easily, and the upper portion of the flask to be removed without disturbing them. This "leader" is clearly represented at *c*, Fig. 134.

Filling Upper Portion of Flask.—The teeth may now be removed—having served up to this point as a protection to the delicate edges of the wax model. Each block or single tooth must be carefully separated from the wax, and if any of the plaster covering of the pins should remain in the wax, these should be carefully picked out; and should any other

damage have occurred, it should be repaired before further proceedings. The whole surface of the lower portion is now carefully oiled, after which it will be of material advantage to place it over a small gas flame or other warm place, so that it may be gently heated to about blood heat, or a little higher, but not sufficient to endanger the melting of the wax. In the meantime, two ounces of pumice is boiled as directed in casting the matrix, and one ounce of plaster is added. The whole is well mixed, made quite thin and should be warm, but not much above blood heat. With the sable-hair pencil, portions of the composition should be worked into the minute recesses of the groove into which the pins fitted, as it is very important that no air-bubbles should lurk in them. The upper portion of the flask is now put in place, more of the composition is added, and worked in with the brush, if necessary, until the ring is filled. All, up to this point, should be done before any signs of setting appear in the composition. The heavier portions sink, and as the water runs off the remainder is added; when it begins to stiffen, the composition is piled up on the centre so as to form something of a convex surface. The top of the flask is now put in its place; the middle of the arch formed by the raised letters, being placed over the centre of the gate. The flask is now placed in the clamp or stand, and the screws tightened upon it so as to insure a complete closure, when the whole is again placed in a warm situation. This warming of the flask and the liquid composition is of advantage in expanding the wax of the model, which, compensating for the shrinkage of the aluminium, allows the teeth or blocks more readily to fit into their places after casting the plate; besides, it also hastens the setting of the plaster.

Opening the Flask and Drying the Mold.—When the composition has completely set, the flask is removed from the clamp and warmed gradually, until as hot as can well be borne by the naked hand for a few seconds, (about 110° to 115° F,) but should not be carried higher, as it would en-

danger the melting of the wax, and consequent injury to the mold. The wax requires to be made somewhat warmer though than is usual on opening a flask of rubber work. When it has attained the proper temperature, a thin instrument is inserted, the parts carefully separated and slowly drawn apart. The plate will most usually be left in the upper portion of the flask, and the film of the varnish will frequently come away wholly or in part, and any remaining portions of the varnish are removed at once. After a little cooling, the wax-plate is lifted at the corners and gently pulled away. If any large portions of the wax remain in the narrow interstices of the mold, they should be pulled away, if this can be easily done without disturbing those fragile portions of the mold along the line of the teeth; but should there be any danger of this, it is far better to let them remain and be absorbed than to risk the injury of those delicate portions, or the danger of clogging up the narrow crevices by detached grains of pumice, &c. The "leaders" and other portions of wax being also removed, the two halves of the mold may be placed on the gas or kerosene stove, (with about as much flame as is used with an ordinary two case vulcanizer,) until thoroughly dried. The flask should be placed some distance above the flame, and after the superabundant moisture has evaporated, it should be kept at about the temperature a laundress keeps her iron—which may be tested in the same way, by the contact of a wetted finger—until thoroughly dry, which will be from one to two or three hours according to the intensity of the heat. Cases that are ready to dry in the evening, may be left over the heater all night, provided the heat does not rise above that mentioned, (about 300° or 350° F.) The wax that may have been left in the mold is all absorbed by the composition as the flask is heated, but the heat should not cause the wax to smoke and become charred, as this would cause the composition of the mold to become exceedingly frail, and if the heat were carried still farther it would shrink in volume and become cracked.

Casting the Plate.—*Heating and Melting.*—The best furnace for heating the fire-clay conduit, would be one constructed of sheet or cast iron, lined with fire-brick, having an internal capacity of one foot in length, six or eight inches deep and six or eight inches wide. The furnace known among stove dealers as "Oval Furnace, No. 3," answers very well, but there might be some improvements made that would better suit it to our purpose. The furnace mentioned may be conveniently used in the open air, by attaching two joints of pipe, or it may be connected with a flue. A fire first built of coke is preferable, on which the conduit is laid and frequently turned, so as to heat up gradually, when it may be covered with charcoal and occasionally turned until this is ignited, when the cover of the furnace is put on and the fire allowed to burn until the conduit becomes red hot throughout its whole length. At the same time, the metal should be melted in an ordinary Hessian crucible, which may be placed in the same fire with the conduit. An ordinary *grate* with a blower for burning hard coal, is found to answer admirably, both for heating the conduit and melting the metal.

Preparing the Mold for Casting.—While the conduit and metal are heating, the flask containing the mold should be gotten ready for casting. Having become sufficiently dried, and still at the degree of heat before described, the lower portion of the flask containing the matrix should be grasped at its side with a small hand-vice, so as to hold it securely, and with the blowpipe and a gas or alcohol flame, go all over the surface of the matrix with a sharp quick dart of the flame heating up the surface just enough to burn away the oil and wax that may be upon it; but it should not be heated above a dull red at any point, or the pumice will be crisped and rendered rough on the surface. This operation is intended to drive off the gasses that would otherwise be formed at the moment of casting the metal into the mold, which would cause the casting to "blow." It might in some cases be neglected where there has not been much absorption of oil or

wax, but it is at any rate an important precaution. The other side of the flask is now grasped by one of the projections for the vents, and this in like manner carefully gone over with the blowpipe flame. If the vice has been properly attached, this upper portion may now be easily placed upon the other half, in its proper position, and the vice being removed, the flask is pressed together. The vents should now be tried into their places and immediately removed, when, if there is any suspicion that loose particles of pumice have fallen into the mold by closing it or introducing the gates, the flask should again be opened by means of the vice, or the hands shielded by a thick cloth, and every particle of loose sand, etc., removed by blowing and brushing with a soft brush of camel's or badger's hair. The flask being again closed, is placed in an upright position in the stand or holder, so that the gate is as near vertical as possible, and the top or cover of the flask facing the screws. The thumb-screws are now tightened until the flask is thoroughly closed. Here it would be well again to observe the precaution of inverting the flask with a shaking motion so as to allow any loose particles to escape at the gate or vents. The flask and holder are now placed over the gas or kerosene stove, and the flame allowed to play directly on the point of the gate, and by the time this has become red hot, all should be in readiness for casting.

The stand containing the flask is placed in a shallow iron pan, for safety against the overrunning metal, and the waste-cup is attached by passing the vents through the holes in the plate attached to the cup, and into their places. The cup should hang on the back part of the flask so as to rest solid and level, yet not interfere with the gate or vents. The vents should be previously examined to see that they are properly filled with the small rods or wires, and that a free passage of air is secured through them.

The conduit is now lifted from the fire with the tongs provided for this purpose, previously warmed, to prevent crack-

ing the hot conduit, and by means of a tube, etc., any dust or loose particles are blown from it by the force of the breath. See that the end previously fitted to the gate is clearly identified, then it is placed upon the gate, and settled down in position. If the conduit should not stand perpendicular, this may be quickly remedied by placing something under the edge of the iron pan. One of the clay gates having a rubber tube connecting with the gas supply, is now introduced into the top of the conduit, and held by the hand of an assistant or by means of a weight or spring compress. The gas is turned on, and should it take fire, is turned off for an instant, and again turned on, until it does not take fire. The gas should run freely and constantly until the metal is ready to pour in—twenty or thirty seconds are amply sufficient.

Pouring the Metal.—This is the grand climax of the whole foregoing series of operations, and on it now depends success or failure. The crucible should have been filled with at least three ounces of aluminium in *solid pieces.* No scraps or fragments of other plates should be added to a melting for this purpose, but should be laid aside for refining as will be hereafter described. The metal should have attained a full red heat, and now should be a dull red, but still quite fluid. If the metal is too hot, the casting will be rough and more porous, and if too cool, the minute portions of the mold, or very thin plates, do not readily fill out. The skillful operator will soon learn the proper heat to make the most perfect casting. This point is of the utmost importance in all kinds of metallic castings, especially in brass, but of even more importance is aluminium.

All being ready, the crucible is lifted from the fire, and any loose particles blown from the surface of the metal. As the lip of the crucible is brought to the top of the conduit, the gas pipe is quickly removed, and the metal is *instantly* poured in—*quickly, yet with as much deliberation as the case will allow.* After the first tipping of the crucible, follow up the movement without any stoppage or cessation until the

whole conduit is filled to the top. After a little practice, a skillful hand will turn in the metal and follow it up with the remainder so closely and rapidly, yet with such discretion, that the conduit is filled to the top from the first, and remains full but not running over, until the metal fills the mold and enters the vents with a hissing sound; such a condition is the most desirable, and will in ninety-nine cases in one hundred produce a perfect casting, provided the mold is properly made.

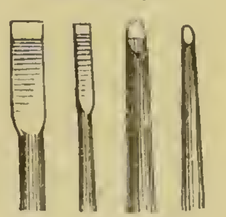
As soon as the mold and conduit are full, if there is no leakage anywhere, the crucible is returned to the fire, and after the lapse of ten or fifteen seconds, the conduit is grasped with the tongs, and by a dexterous movement it is detached from the gate and instantly held over the waste-cup, where the metal will be caught as it drops from the conduit. After a slight tap on the flask or pan to remove any remaining metal, the conduit is returned to the fire, to cool gradually. As soon as the conduit is removed, while the casting is yet hot, the vents should be grasped with the hand, shielded by a cloth, and forcibly twisted around until they come away (which they will do easily if not too tightly put in), breaking off the vent leaders, and bringing away the portion of metal that has gone into the cylinders and among the wires. The flask should now be left to cool. The cooling may be hastened by sprinkling water on the flask, or the whole may be plunged into a vessel of water, but this might in some cases cause the plate to be warped or otherwise damaged by the sudden and irregular cooling.

FINISHING THE PLATE.—*Clearing away Gates, Vents, etc.*—As soon as cool, the flask is opened, when the plate is easily removed from the now soft composition of the mold, the clay gate being attached and coming away with it. If it is desired to preserve the clay gate and melt the metal from it, this should now be cared for by wrapping it with sufficient cloth or paper, before putting it into the vice, to prevent crushing. But these clay gates can now be furnished with a

tapering bore by which they may be made to slide off from the metal. The vents and gate may now be removed by a mainspring saw—such as are used by watchmakers—and all "fins" and other protuberances of superabundant metal, may be cut off in the same manner and preserved among the scraps. It may be necessary to state that when sawing off a gate or other protrusion of metal, it is generally better to fasten the portion to be removed in the vice, and leave the plate free, to prevent springing. The outside rougher portions of the metal may be removed with a coarse file, and the thick portion of the plate, where the gate was cut off, may be readily reduced by the bur cone fixed in the lathe, or the file-cut wheels, which are described on page 192, S. S. White's catalogue. These burs or files cut better when oiled, or wet with water.

Fitting Teeth to the Plate.—The next operation in order is fitting each block or single tooth into the place cast for it on the plate. This operation requires judgment and skill, and may at first seem difficult, but a little practice will enable any one handy with tools to do it very rapidly. A short hog-hair brush is provided, rather smaller than the larger one represented in Fig. 125, p. 367; also a mixture of chinese vermillion and olive oil. The vermillion should be dry, and mixed only with olive oil into as stiff a paste as can be worked with the brush. There should also be provided several small gouges and chisels, having points of the size and form represented in Fig. 135. These may be made of old excavators or other useless instruments, and should be well tempered.

Fig. 135



If the previous operations have been carefully done, the blocks or teeth will often go readily into their places without any cutting, but there are many small projections of metal that require removal. The most prominent of these may be cut away at once by the chisel or gouge, and any metal that would overhang the upper edge of the gums when the blocks are in

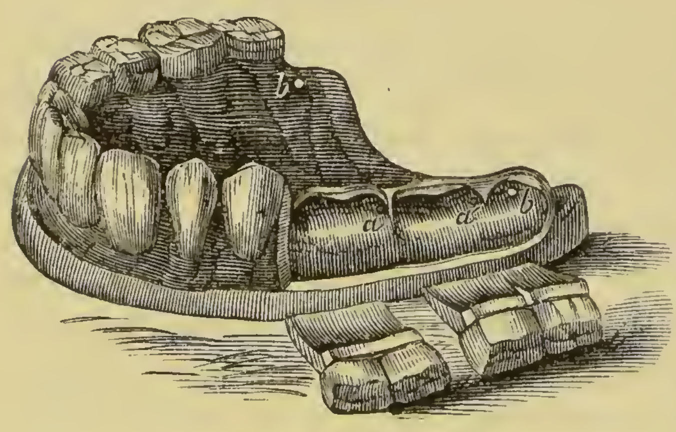
place, should be cut away, so as to present a square edge against which the blocks or teeth rest and fit closely; as a nice fit, and a graceful line here, adds much to the beauty of the work. The tooth or block to be fitted, is now cleared of the plaster investments of the pins, smeared with the vermillion paint on the surfaces that are to be fitted to the metal, and is pressed into its place; when removed, the points at which it touched are plainly marked and can be readily cut away. The block is again freshly painted and tried into its place, when the markings are again cut away. After repeating this operation a few times, and cutting *only where the piece* touches, the block or tooth will be found to fit closer and closer into the place designed for it, until the fit is satisfactory, and the next in order is proceeded with in the same way. In blocks or single gum teeth it is generally found best to fit the upper square edge of the gum first, then the pins go into place readily, and the fitting is soon completed. Particular attention should be paid to the neat fitting of the plate along the palatine edges of the teeth on the inside of the arch, and in this the burnisher may sometimes aid in pressing up the thin edges of the plate; but care should be taken not to alter the position of the teeth by this means. The septums or barriers, along the channel between the blocks and pins, should be preserved with care, and no more metal removed than is absolutely necessary. When each tooth or block has been fitted independently into the place cast for it in the plate, it will be found when all are applied, that they will impinge on each other so that they will not go entirely into their places. This is caused by the contraction of the plate in cooling, and can be turned to a valuable account, as it affords just sufficient room for grinding a very little from each block in order to perfect the joints between each piece. In the hand of a skillful operator this may be carried to great perfection, and with the admirably molded blocks that are now produced by the manufacturers, we can thus make a case that in the mouth would show no more joints than continuous gum work.

Filing, Scraping and Polishing.—The plate and teeth should now be thoroughly washed with a stiff tooth-brush and castile soap. Then trying in the blocks, one at a time, by filing, scraping, etc., along the edges where the metal joins them, these joinings of the teeth and metal, may be neatly adjusted so as to present a much more pleasing appearance than if done after the teeth are permanently in place, as in rubber work. The rim and outside edges of the plate are smoothed and fashioned with the file, the palatine portion is mostly scraped to a surface with the ordinary scrapers used for vulcanite. The finer files, cut best with oil, but the metal must frequently be brushed from the teeth of the file by a jeweller's scratch-brush. The palatine surface of the plate should be finished with great care, in order to produce a good effect. The previous manipulation of the wax patterns should have been such that there will be but little to take from this surface now; only to make it smooth and even. The scraper should be quite sharp, and the edge free from gaps—and as there are no teeth on the plate to dull the tools, they can be easily kept sharp. The surface of the plate is frequently smeared with olive oil, which causes the tool to cut with the greatest ease and smoothness. All deep scratches, must be carefully avoided. Emory paper of different grades, applied with oil will give further smoothness to the surface. Small wheels fixed in the lathe made of thick sole-leather, or better of sea-horse leather, and charged with fine flour of emory and a little tallow, are found of very great service in polishing. The final finish is given with a felt-wheel, dry, or with a very little tallow, and charged with the finest flour of emory. A very fine surface may be obtained by stoning with Scotch or Ayershire stone with water, until all the scratches are removed, then polish with the felt-wheel and fine flour of emory. The upper surface of the plate, of course, should not be touched, but if there is a chamber, this should be scraped, stoned and polished; which adds to the beauty of the work.

It is best at this point in the series of operations, to drill through the *septums* before described, and to make such other undercuts and retaining points as may be needed. This is done by means of a small drill fixed in the lathe, or it may be done by a small excavator drill, rotated with the thumb and fingers as in excavating a decayed tooth. All the barriers along the groove into which the pins fit, should be drilled through, so as to form a continuous channel for the introduction of the solder by which the teeth are united to the plate. Fig. 136 shows very plainly an upper set of teeth full size, with all of the blocks on but two, preparatory to securing them permanently.

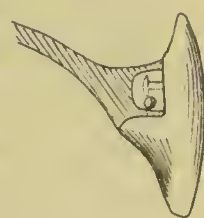
Where the two blocks have been removed, the recesses are shown into which they fitted, with a septum a, between the blocks, and also a projection between the pins of the molar blocks at a'—these are drilled through as represented, the holes usually being about the size as at a and a', but should be made as large as is consistent with the requisite strength of the remaining metal. Then at each end of this groove or channel, a small hole is drilled through the backing, as it were, to the palatine surface of the plate, as represented at b and b'. The drilling is always most easily done when the part operated upon is well oiled—without oil, the drilling is very slow. Care must be taken not to pierce through the palatine surface of the backings in drilling; where there is danger of this, the septum may be drilled into from both sides, until the two meet. Sometimes it is of advantage to secure additional undercuts or retaining points along the edges of the

Fig. 136.



channel, by drilling into the thicker portions of the plate along the sides; but this is seldom necessary. In partial sets, where the teeth are scattering, and single teeth stand alone, the tooth is fitted into its place, while the pins fit into a recess in the backing, and the backing, as in a similar case of rubber work, fits closely to the tooth. The sides of this little cell or recess into which the pins project are drilled through and countersunk on the outside. Fig. 137 is an enlarged representation of a single tooth, with a section of the cell or recess into which the pins project, and having the hole drilled in its side. This will serve to give a more definite idea of what is desired to be described.

Fig. 137.



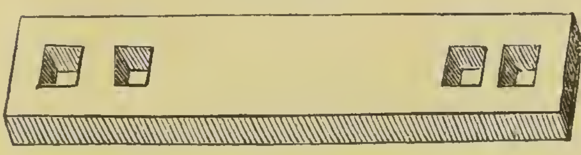
When the "burs" made by the drilling are removed, the plate should be thoroughly polished by the felt-wheels and fine flour of emory or rotten-stone before mentioned. By using wheels of different and suitable sizes, with fine washed flour of emory; for the last polish, a very brilliant finish may be given to the plate. The burnisher as yet, in the hands of the writer, has not had a good effect in finishing the work; but it may yet be made useful.

Securing the Teeth to the Plate.—*Adjusting and Attaching with Wax.*—The plate now finished and polished, is washed clean of all grease, etc., by means of a stiff brush, with castile soap and warm water. The teeth or blocks are also washed clean, and again placed in their proper position on the plate. The plate should be dry and warm, and as each block is added, it is secured by a little pure yellow wax, melted on a wax-tool, and heated over the flame until it begins to smoke; and by applying it along the edges where the blocks and metal join, it will run in and secure the piece sufficiently firm. After the teeth are all on, the piece may be tried in the mouth if necessary, before fixing them, as there is still room for some alteration in their position. All being satisfactory thus far, the superfluous wax must be removed, ex-

cept where it is desired the solder should flow—for the minutest portion of wax left, will be faithfully represented by the metal that is injected into the channel. Two little cylinders of wax, about one-sixteenth of an inch in diameter and three-fourths of an inch in length are provided, and one of them is set up immediately over each of the small holes b, b′, Fig. 136. They should be secured by melted wax, and bent so as to stand vertical when the plate lays on a level surface with the cutting edges of the teeth upward.

There is sometimes a difficulty about cutting off the metal which afterwards fills the place of the small wax cylinders, without drawing a portion of it away from the holes b and b′ Fig. 136,—thereby allowing these holes to remain visible. The iron conduits and brass gates are heavy, and after the injection of the solder, they are attached to the plate by means of the little cylinders or *leaders*, and are awkward to manage. A very successful way of avoiding this, is to provide a small metallic bar, say of iron, or better of aluminium of the size and form represented in the cut, Fig. 138, (being about one-tenth or one-eighth of an inch in thickness.) Three or four square apertures are made in it as represented, in shape like the frustrum of a pyramid—in the figure, the base, or the larger portion of this hollow frustrum, is represented as uppermost. One, made as represented in Fig. 138, would accommodate four different widths of plates and might be sufficient for most cases. This bar is placed upon the crowns of the last molars (in a full set), with the *smaller side* of the holes uppermost, and so as to admit through two of them the wax cylinders previously set up over the holes b and b′, Fig. 136. The bar is secured in placc by entirely filling the holes through which the cylinders project, with melted wax. Thus it will be seen, how, when the metal has been injected and become solid, the gates

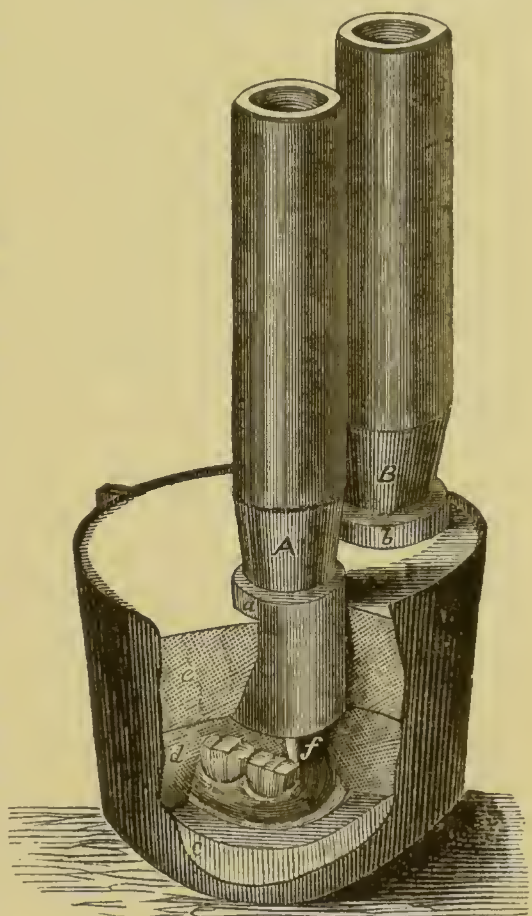
Fig. 138.



and conduits may be twisted off before the set is taken out, without disturbing the portion below the square holes in the bar. Then, by reason of the pyramidal shape of the holes, the bar is easily removed after the piece is taken out of the investment.

Investing the Set for Soldering.—Fig. 139 gives a clear idea of the set invested with the plaster and pumice composition, preparatory to injecting the solder for securing the teeth. A portion of the iron ring and composition are broken away, to show the internal arrangement. The iron ring has a movable clasp by which it is held together, and this should be made so as to be conveniently removed when the ring is to be opened.

FIG. 139.



The inner portion of the plate is now filled with the composition of pumice and plaster, before described, and, as it begins to set, is heaped up so as to rise above the edges of the plate, and serve to support and elevate the set when placed with the teeth upward, as at *c*, Fig. 139. The set is now placed upon a level surface, and the ring placed over it, being careful not to disturb the teeth, and another portion of the composition is poured in until the crowns of the teeth and the metal bar, if used, are entirely covered, yet the wax cylinders projecting above the surface. In the figure, the two molar teeth of the

plate, shown uncovered, gives a definite idea of its investment, in the layer *d*, with the cylinder of wax at *f*, leading into the brass gate *a*. The metal bar described is not shown in Fig. 139, but its end would appear near *f*, between the layers *d* and *e*. As soon as the layer *d*, or the investment proper, has set sufficiently, by means of a hot wax-tool, the projecting cylinders are melted down even with the surface, and the wax spread around a space as large as the smaller aperture of the brass gates *a* and *b*. These brass gates are now warmed, and placed with the smaller apertures downward over the ends of the wax cylinders, so that the channel will certainly communicate with the gate when the wax is melted out. The gates, being warmed, imbed themselves in the wax, thereby closing the lower aperture water-tight, for this is very important, to prevent the composition rising in them, which would endanger their obstruction. The last layer of composition, *e*, is now mixed as the others, and poured in; it should fill the ring to near the top of the brass gate *a* and *b*, as represented.

Drying and Injecting the Solder.—As soon as thoroughly set, the whole, except the *iron conduits* A and B, Fig. 139, is placed over the heater, and gradually dried. If placed on its side, most of the wax in the cylinders will run out at the gates, and the trifling remainder will be absorbed by the composition. When the wax has all melted, it is well to insert one of the conduits into one of the gates and blow through, to be assured that there is an opening all the way round to the other gate. A small hole is now made in the the centre of the upper layer, *e*, Fig. 139, nearly through it, into which a slip of fusible metal, or tinner's solder, is placed. When it has become sufficiently hot to melt *Wood's "plastic fusible metal,"* which fuses at about 220° to 230° F., it is entirely dry, and should be heated a while longer before the metal is poured in. When Wood's "*fine solder*" is melted, which fuses at about 300° F., the piece is quite hot enough, and should be gotten ready to pour the metal. The iron

conduits A and B, Fig. 139, should have been heated up over a lamp flame or small charcoal fire, until almost red hot; but they should never be made red hot, as they would be injured thereby. The metal to be used is usually composed of pure tin, with 25 per cent. of cadmium, or 8 or 10 per cent. of silver. The cadmium alloy has some advantages in use, on account of its fluidity and lower fusibility. This metal or solder should now be in readiness, melted in an iron ladle, and heated until olive oil thrown on its surface smokes and almost takes fire.

All being ready, the conduits A and B, Fig. 139, are placed in position in the gates, and the metal poured into one of them, which is filled to the top, until the metal is seen to rise in the other, when it also is filled to the top, and the whole left to rest for a moment, when a wet cloth is applied to the outside of the ring, so as to cool it as rapidly as possible; but great care should be taken to prevent any water running under the edge of the ring, and arising in the composition, as it would endanger the cracking of the teeth. If by reason of the case not being hot enough when the metal is poured in, it does not rise in the other conduit, the whole should be placed over the heater, and the temperature raised as rapidly as possible, at the same time blowing a flame upon the conduits to preserve their temperature, and occasionally lightly tapping the outside of the ring, to make the metal run, until it settles down. If it does not settle down, then fill up the other conduit, and after a moment's rest apply the wet cloth as before directed. By this means the metal in the channel is first cooled, and the shrinkage is supplied by the superposed column of melted metal.

When all is cool enough to handle, if the metallic bar, Fig. 138, has been used, the conduits and gates may be turned round in the composition until the leaders are twisted off, and they come away. If the metal bar has not been used, a block of wood should be placed between the conduits, and the two tied together for stability. The clasp may now be removed,

the ring opened, and the case taken out from its investment. If the gates and conduits are still attached, the "leaders" should be carefully sawed off by the mainspring saw. As a precaution against getting dirt or any discolorations in the joints, these should now be filled with castile soap rubbed over them, or liquid silex applied and dried into them.

All superfluous solder should now be removed, with graver's files, etc., and as the polish may be slightly dimmed, this should be renewed by the dry felt-wheel, and very fine washed flour of emory. By carefully cutting away the tin, and burnishing down the remainder in the small holes where it was injected, these may be almost entirely hidden from view. Or, if it is desirable, these holes might be drilled out, tapped, and small plugs of aluminium screwed into them.

Great care should be observed to avoid the contact of *mercury* with the plate, especially in finishing, for a fresh surface of aluminium will unite with mercury, and the spot *amalgamated* is liable to the action even of the fluids of the mouth, yet strong nitric acid dissolves off the mercury and stops the action.

It only remains now to wash the plate with soap and water with a stiff brush, when it should have the fresh brilliancy of silver. The unpolished portions may be rendered white and clean like frosted silver, by carefully applying to the surface a saturated solution of caustic potash, by means of a spun glass pencil, (such as are used for applying lunar caustic,) as it would soon destroy a brush made of hair. Care should be observed not to allow the potash solution to get on the polished surface, as this would spot and dim it. After remaining from one-half to one minute, the potash is washed off, and applied again if necessary.

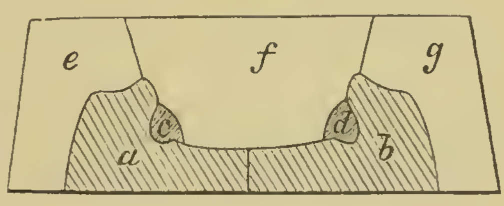
The case is now completed, and if the directions have all been properly followed, it will be a more perfect denture, taking all of its excellencies together, than can be produced by any other process now known to the profession.

Casting Shells for Lower Sets.—In the foregoing portion of this chapter, the instructions laid down relate almost exclu-

sively to the construction of upper sets on aluminium, as this was considered the best method of avoiding complication. The metal itself, and the foregoing system of constructing a denture on such a base, is equally applicable to *lower sets*. But as *lightness* is a great desideratum in an upper set, so also is *weight* as great a desideratum in a lower set. Then to construct a lower set in uniformity with an upper set on aluminium, and give it also the requisite weight, we must cast a "*shell*" of aluminium, upon which the teeth are accurately fitted, and into this shell is injected by the apparatus already described, a filling or loading of heavier metal, at the same time, the teeth are firmly secured in place.

The *impression* of the lower jaw, taken in plaster as previously directed, is prepared and surrounded with a rim of wax, as described on page 366; and as almost all lower sets have some "undercuts" on the lingual side of the posterior alveolus, it will usually be necessary to make the model in two pieces, by means of the leaden septum described on page 368; but the shape required will be somewhat different from Fig. 126. The division should be along the median line, and the middle portion of the model should be sufficiently thick to give the requisite bearing to the joint. Where the undercut at the posterior portion is considerable there would be a difficulty in separating the middle portion of the mold from the matrix, when the latter is cast, if this be not provided for. Fig. 140 illustrates the point under consideration—*a* and *b* represent a section of the two parts of the model, and *c*, *d*, *e*, *f*, *g*, parts of the mold. The undercuts *c* and *d* are first filled with plaster, which is trimmed in the manner represented, so as to make these points flush and full, and completely obliterate the undercut. Then after the parts *g* and *e* are formed, the pieces *c* and *d* being properly varnished, &c., are pressed into their places, and the middle piece, *f*, cast in between.

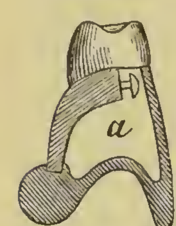
FIG. 140.



As *f* expands, the joint between *a* and *b* will yield to it, and when all are separated, *c* and *d* can be detached from their places on *f* and again accurately replaced when preparing to cast a matrix; then they should be stuck with very little wax, barely enough to hold them in place; and as the part *f* of the mold is removed from the matrix *c* and *d* will be left, and can be afterwards removed.

A *false model* should be cast, and upon this the pattern plate is formed, as also the plate for taking the bite. The false model can be arranged in the brass articulator before described, and in connection with an upper set if desired. The teeth are ground as described for an upper set, arranged in the usual way, and secured with wax only along the lower edges of the gums of the teeth or blocks. The pins of the blocks do not require to be invested with plaster, but after being oiled, all the space between the plate and tooth, as represented in Fig. 141, *a* is filled with plastic clay or kaolin, mixed with a little fine pumice. This clay is filled in, and modeled over the pins, etc., leaving interstices between the blocks for septums or retaining points; and this must be so shaped, that a thin sheet of wax applied on the inside or lingual surface, will complete the proper form for the base. This inside portion of the shell is represented in section to the right of *a*, Fig. 141; it should be of very pure wax, carefully formed and neatly modeled around the necks of the teeth, while hot wax is run in between the blocks to form the septums or retaining points, which latter, however, are not of as much importance as in upper sets.

Fig. 141.



When the teeth or blocks are removed from their places on the model base, the clay may all be washed out by a forcible jet of water, or some such means, and the teeth may be placed back in position. The investment should be same as directed for an upper set, taking care to fill completely the space previously occupied by the clay in completing the upper portion of the flask. In making the *leaders* to the gate and

vents, the latter should attach to the highest points of the wax model, and that from the gate should be about the size of the orifice of the clay gate, and should connect with the middle of the front lingual portion of the wax model. Sometimes it might be well to lead two lateral branches connecting with the sides of the model base.

After the *shell* is cast, the teeth are fitted with great ease and facility. A few retaining points along the inner wall of the shell are sufficient. The solder or composition of tin and silver is injected in the same manner as already described, filling the whole space or cavity around and under the teeth, thereby securing them firmly in their place, and at the same time giving sufficient weight to the piece to enable it to be easily kept in the mouth of the patient. Additional weight may be given to the piece by filling the space under the blocks with platinum pins, or any small fragments of platinum, and under a sufficient degree of heat, the solder is injected, so that the pins are completely enveloped and combined in one mass by the tin and silver, and as the whole is so completely shut out from the fluids of the mouth and so completely enveloped by the shell of aluminium there is absolutely no opportunity afforded for any galvanic action that may have been feared by some. To cause a galvanic action, *two dissimilar metals in contact, must both be exposed to the action of a fluid*—hence, if one metal is enveloped by the other this condition of things cannot happen.

In making large "*plumpers*," they may be cast as a hollow shell, separately, and attached to the side of the plate in the same way, and at the same time the teeth are fastened.

Repairing Aluminium Work.—It is at once evident that this work is more easily and more perfectly repaired than any other. If a tooth or block is broken, the best and most effectual way to repair it is to remove all the rest of the teeth, if a full set, by holding the plate over a lamp flame, gradually heating it up to the melting point of the solder, when all of the blocks or teeth may be removed, and the old

solder brushed away. The operator will now have an opportunity to fit in a block as perfectly as was the original, provided it is from the same mold, and as it is but little more work to solder all, than one block, in consideration of the superior result, this is certainly the best plan. The case is invested as before described and the solder injected. If the retaining points should be broken away these may be supplied by screwing in between where the pins go, small steel screws with heads, such as used by watchmakers. Such a thing as a crack or split in the plate will probably never happen; but should that occur it would be most easily repaired by riveting a plate of aluminium over the crack.

Casting Lower Sets of Tin and Silver.—Where expense is a consideration, a lower set can be constructed on a base composed of the alloy of tin with 8 or 10 per cent. of silver, combined in the manner hereafter to be described.

The mold for casting the tin composition may be made of equal portions of plaster and pumice, and the matrix, by observing great care in the manipulations, may be cast into the impression. And this is the desirable method, since the tin does not contract as much as aluminium, if it were cast in a mold prepared as directed for that metal, it would be too large for the gums, to make a good fit. The composition used is stronger too than that used for the aluminium mold, and where the impression is taken in a special cup, prepared as has been already described, the impression can be easily removed without injury to the matrix cast in it. The model set is prepared as for rubber (except the teeth should be ground with a square edge on the gum), and invested with the composition of equal portions of pumice of the size already described. The teeth are left on the wax model, and invested with it in the flask used for aluminium, but some peculiarities are requisite for the *leader* from the gate. There should be a large mass of wax placed between the two sides of the piece, connecting with the gate by a large piece, and with the sides by smaller pieces of wax. The object of this is to

furnish a mass of metal from which the shrinkage may be supplied, and which will be last cooling, so that no defects from shrinkage may exist in the base itself. The clay gate is used same as for aluminium, and the vents are attached in the same way; but the conduit need not be more than three or four inches in length, and should be heated to a dull red. The end of a broken conduit may be used. This will give sufficient pressure for tin. The flask should be heated up till quite dry, but need not be over 300° or 400° F. The metal should be as hot as that used for injecting for soldering a piece.

When cast, the piece will be found solid throughout, the teeth firmly attached, and the gates having been sawed off, it only remains to finish up the metal with files, emory paper, burnishers, &c., and we have completed a lower set that will be as pleasant, as lasting, and as serviceable, as any other that can be made. The alloy stands the action of the fluids of the mouth much better than silver, and probably the only objection to it is the cheapness of the material.

Lower sets might be cast of solid 18 carat gold, by means of this apparatus, and the teeth fitted on as described for aluminium upper sets, except that the channel may be continuous, without the septums, and the teeth soldered on by injecting the solder into the channel after having been tinned. By stopping up the holes where the solder was injected with plugs of gold, the whole of the solder might be entirely hid from view, or contact with the fluids of the mouth, and the piece would also have ample weight to hold it in place. If expense were no object, this certainly would make a most elegant piece of work.

For Partial Lower Sets, the writer has devised a method which he has used in practice for several years past with the most perfect success, in cases where the lower front teeth are remaining, as is generally the case with partial lower sets, and there are vacancies on each side. The impression is taken in plaster with a special plate, prepared in the manner

already described, so as to take an accurate impression of the vacancies as well as the lingual surface of the gums along the incisors, and in this is cast the matrix, of equal parts of pumice and plaster. The teeth are arranged and articulated as directed for the tin and silver work, and the two portions of the model set are secured in their proper places on the matrix. These two sides should have previously been held together by a strip of wax or gutta-percha passing behind the front teeth, and strengthened by a temporary spring, of steel or other metal. This strip and temporary spring are now removed, and their place supplied by a spring of steel, carefully made of the best Stubbs' wire, flattened, neatly fitted to the contour of the lingual gums, from one side to the other, by bending with pliers, etc., and the two ends bent so as to be imbedded in the body of the base on each side. The steel spring should be rounded up on the edges with the file and reduced to proper shape and size. It is then tempered a good spring temper. This is done by heating it uniformly to a cherry red, after covering the surface with a coat of soap, and suddenly to plunge it into cold water covered with a layer of oil one-eighth of an inch thick. This will make the steel very hard, and as brittle as glass, but the oil on the water prevents it from springing out of shape. It is now "blazed off" by placing it in an iron spoon, or something similar, with sufficient olive oil to cover it; the spoon is held over a flame until the oil takes fire; the oil is allowed to burn freely until all consumed, and just as the last portion burns away the steel is thrown again into the water. If the operation has been properly performed, the steel will now be found to possess an excellent spring temper. It is carefully cleaned by file, emory paper, &c., until quite bright, when the surface is covered with muriate of zinc, or "soldering fluid," and immediately plunged into melted tin, sufficient to cover it—taking care not to heat it above the point at which it was "blazed off." The last operation gives the steel a complete coating of pure tin. The spring is now placed in

its proper position on the matrix, to see that it fits properly; two bits of fine binding wire are wrapped once around and twisted up, one near each end of the spring—the twisted ends pointing inward. The ends of the spring are now imbedded in the wax of the base, and secured by a little wax along the edges to prevent the plaster from running under it. The case is now invested in the flask as before directed for tin work. When the flask is opened, the teeth will be found imbedded, as in rubber work, and the steel spring also, secured by the bits of binding wire imbedded in the composition. The mold is dried and the piece cast as previously directed, of the tin and silver alloy, or of pure tin. The two sides will be found firmly united by the tinned steel spring, and the metal will be found to have filled up between the spring and gum so as to make an accurate fit to the latter. Such a piece carefully finished and adjusted, has given greater satisfaction in these peculiar cases, than anything the writer has ever employed. A similar spring not tinned may be cast on to an aluminium base, or "shell," in the same manner, and afterwards tinned.

Mending Defects in Aluminium Plates.—It may sometimes happen that small holes or other defects may occur in an aluminium plate, and as we have not yet been able to find a solder that will firmly unite with the metal, these defects must be otherwise remedied. Where the hole is less than one-tenth of an inch in diameter, it may be counter-sunk on each side, and filled by a rivet of aluminium nicely fitted and carefully hammered down so as to fill the vacancy. In small holes, this method most effectually remedies the defect, and may be finished without leaving any evidence of the repair having been made. Holes that occur in the portion covered by the teeth, will be filled by the solder which is injected to secure them to the plate. It may be sometimes necessary to cut a thread in the hole by means of a tap, and screw in a plug of aluminium.

Amber Japan.—When aluminium plates have scales or

blisters, as in wrought plates, or where there are sand-holes, flaws or other interstices in cast plates, it has been found that these cavities are liable to be acted on in some mouths in the same manner as the natural teeth are attacked by caries. This is undoubtedly, in the case of both the teeth and the metal, the effect of the chemical action of the acids generated by the decomposition of food and the secretions of the mouth which accumulate in these localities. The remedy is the same as for decaying teeth—these interstices and cavities when they exist, must be filled, and the plate must be kept clean with the brush.

All considerable defects must be repaired in the manner already described, and to insure a filling of all smaller interstices so as to be impervious to the fluids of the mouth, the following has been found entirely successful:

Take four ounces of amber varnish, or best "coach body" varnish, and one-half ounce of fine flowers of sulphur. Heat slowly together in a tin or porcelain cup until the sulphur is dissolved. The heat should not be carried above the boiling point of water; as soon as a drop of water dropped into the varnish boils up, it is hot enough. The set of teeth completely finished, should now be carefully cleaned by brushing and boiling in water with a little castile soap, and then in pure water, when it is placed in the varnish and heated until the water adhering to it is boiled out—being careful not to melt the solder or burn the varnish. The cup is set aside, and as it cools the liquid japan is absorbed into every minute pore of the set. When cool enough to handle, it is taken out, the superabundant varnish wiped off and every portion of it carefully removed from the surface of the plate and teeth by means of a linen cloth moistened with spirits of turpentine. The varnish may be prevented from entering the joints between the teeth or blocks by previously drying the set and filling these joints with thick gum arabic mucilage, and allowing it to dry completely before putting into the varnish.

The set is now placed in the oven of a common cooking

stove or small heater, where it will be exposed for one or two hours to a heat of about 230° to 250° F. If the heat is carried above this point the japan will be darkened and burned, or the solder may be melted. The baking completely hardens the varnish as in japanning, and effectually excludes moisture from any defects in the set. The surface of the plate may be repolished, if necessary. This treatment stops any action that may have commenced in a plate after being worn, or will effectually prevent it from the beginning. Yet there are but few cases in which it will be necessary to resort to it.

Refining of Aluminium Scraps and Dross.—Aluminium is not injured by frequent remeltings, provided there are no impurities introduced: but on the contrary it is rendered purer by frequent remeltings in a clean crucible without a flux. But always in melting the metal even in a clean crucible, on pouring it out there is left behind more or less dross, consisting of that thin, tough film of oxide that forms on the surface of the melted mass, and generally containing between its folds more or less of pure metal. In making a casting of aluminium, these drosses, and all small scraps of metal should be carefully excluded from the crucible; for the metal being so light, these thin films of oxide are readily mixed mechanically with the metal and causes defects in the casting. For the same reason, pumice powder, charcoal and other such matter should be carefully excluded. All dross, scraps, etc., should be laid aside and carefully preserved from contamination with any other metals until a sufficient quantity has accumulated for a *refining*. Nineteen-twentieths of pure metal may be recovered from such accumulations, by the following process:

Take a Hessian crucible capable of containing the whole of the scraps, etc., and fill it with coarse *Turk's Island Salt*, cover it with a piece of clay or sheet-iron and place it in the fire until heated to a cherry red, when the salt will be found in a liquid state. The dross and scraps are now thrust into the melted chloride of sodium, and the heat urged on until all has

been thoroughly melted, and the mass is a bright red. The crucible is now lifted from the fire and the metal poured out into ingots—(the waste-cup which accompanies the aluminium apparatus serves well as an ingot mold). When all that can be gotten in this way has been poured out, the crucible is returned to the fire, heated again to a bright red, and the mass stirred a little with a slip of soapstone, and left to rest for a few moments in the fire; then removed and left to cool for a while, when it is plunged into a vessel of water. The crucible is of course destroyed, as it would be unfit for any other purpose; the water dissolves the salt from the mass, and there is found a number of globules of aluminium varying in size from that of a musket ball to the smallest sized shot. These may be collected and again melted in a clean crucible, when another ingot of pure metal may be cast. By pursuing this course, with economy, there is but little loss in the use of the metal in the dental laboratory except in filings, etc. But there is great danger of introducing fragments of other metals, such as tin and zinc—this should be carefully guarded against.

Alloys of Aluminium.—Aluminium may be alloyed with most of the other metals, and very readily combines with gold, silver, zinc and copper. The three former alloys may yet be useful in the dental laboratory, but at present it is thought the *pure metal* is the most desirable material for a dental plate. Five per cent. of silver forms an alloy which is probably somewhat stronger than the pure metal, and may not wear away as readily by friction; and, moreover, it receives a somewhat better polish. An alloy with the same per cent. of gold is somewhat similar, but not quite so hard as that formed with silver. Ten per cent. of zinc forms an alloy more fusible that pure aluminium, of somewhat greater specific gravity, but is much more readily attacked by acids or the fluids of the mouth than the pure metal. It has been used with some success as a solder for aluminium. Ten parts of copper with one part of aluminium forms an alloy having

something of the appearance of 18 carat gold, and is very tenacious and malleable; it is used in the manufacture of spoons, dish covers, etc., and is found to resist the action of substances used in the culinary art much better than German silver.

In making alloys with silver and gold, it is best to melt these metals first in a clean crucible, without any flux, and add the aluminium at first by degrees, then the remainder in larger pieces, and after being heated to a bright red the alloy is poured out into an ingot. In making the alloy with copper, which is called *aluminium bronze*, the copper is first melted and the aluminium thrust into it, when after a little stirring the alloy may be cast into molds or an ingot.

Preparation of the Alloy of Silver and Tin.—The alloy used as solder, and for casting lower sets, is composed of pure tin, or the best Banca tin, with eight or ten per cent. of silver. It is prepared in the following manner:

For ten ounces of tin, take sixteen to twenty pennyweights of pure silver or silver coin; melt the silver in a clean crucible, and add the tin, at first in small pieces, stirring the mixture when melted, until one-half of the tin has been put in. It is now poured out on a cold metal plate, again re-melted in an iron ladle, and the remainder of the tin added. When thoroughly melted, it is poured into a vessel of cold water from a height of three or four feet. This last operation produces the form called granulated tin, and causes a more complete mixture or chemical union of the metals; it should be re-melted and granulated in this way two or three times, then poured into an ingot. The melting point of the solder may be lowered, and the metal improved by the addition of fifteen or twenty pennyweights of cadmium.

CHAPTER XVII.

DEFECTS OF THE PALATAL ORGANS, AND THEIR TREATMENT BY ARTIFICIAL MEANS.

DR. KINGSLEY'S ARTIFICIAL VELUM AND PALATE.*

Palatine Defects.—Defects of the palatine organs may be divided into two classes, viz., accidental and congenital. The first includes all loss of substance in either hard or soft palate by disease or otherwise. Such defects are not uniform in locality or extent, being sometimes but a simple perforation of the palate, and at others involving the destruction of the entire soft palate, a considerable portion of the hard palate, the vomer and turbinated bones, and the loss of the teeth.

The second class includes all malformations, from the simple division of the uvula, to an opening through the velum, palatine, and maxillary bones, and a division of the upper lip, thus uniting throughout their entire extent the nasal passages with the oral cavity.

These malformations are quite similar in character, but not uniform in extent. They may be said to begin with the uvula, and in the uvula and velum *always occupy the median line;* but as the defect progresses anteriorly, it may deflect to one side or the other of the vomer, and follow the nasal passage through the lips, leaving the vomer articulated with the palatine bone upon one side; while in other cases the deformity seems to follow the median line, and thus involves

* The descriptions, with accompanying illustrations, embraced in the above chapter were contributed, at the solicitation of the author, by Professor Norman W. Kingsley, and may therefore be relied upon as an authoritative exposition of the most approved manipulations and appliances involved in the practice of that difficult and important specialty of the Dental Art in which the writer excels.

both nasal passages, and terminates in a double fissure of the lip.

In both classes (accidental and congenital) the faculty of distinct articulate speech is seriously impaired by defects of any extent. In ordinary cases of congenital deformity, deglutition is not materially interfered with. The patient having never known any other method of swallowing, is not conscious of any difficulty. Accidental lesions, however, coming generally in adult life, produce, in this respect, very great inconvenience. The remedy for these evils must be the closing of the abnormal passage by some means which will restore the functions to the deformed organs. In perforations of the hard palate, unless of extraordinary extent, the method is very simple. In the loss of the soft palate by disease, the remedy is more difficult, and in extensive congenital deformity, still more complicated appliances will be required.

As we have classified the defects, we shall also classify the appliances used for their remedy.

The term *obturator* will be used for all appliances intended to stop a passage, as all openings in the hard or soft palate which have a complete boundary. Appliances made to supply the loss of the posterior soft palate, whether accidental or congenital, will be called artificial vela or palates.

Obturators.—Any unnatural opening from the oral cavity into the nasal cavity, which will permit the free passage of the breath, will impair articulation. Any appliance which will close such passage, and can be worn without inconvenience, will restore articulation.* Obturators were formerly made of metallic plate, gold or silver being most commonly employed, and many very ingenious pieces of mechanism were

* The student will bear in mind that no cognizance is here taken of openings similar to those described in cases of congenital fissure, where the surgeon has united the soft palate, and left an opening through the hard palate, to be covered by an obturator. In such cases, neither the surgeon's operation nor the obturator will prove of any material advantage.

the result of such efforts, but latterly vulcanized rubber has almost entirely superseded the use of metals. Vulcanite has been found preferable to metals, being much lighter and much more easily formed and adapted, particularly when of peculiar shape.

The steps to be taken in the formation of an obturator are not unlike those used in making a base for artificial teeth. It is essential that an accurate model be obtained of the opening, the adjacent palatal surface, and the teeth, if any remain in the jaw. For this purpose, an impression in plaster is the only reliable means for such an end. Care must be used that a surplus of plaster is not forced through the opening, thus preventing the withdrawal of the impression by an accumulated and hardened mass larger than the opening through which it passed. To avoid this, beginners or timid operators had better take an impression in the usual manner with wax; if this is forced through, it can be easily removed, without injury to the patient. From this wax impression make a plaster model, and upon this plaster model form an impression cup of sheet gutta-percha, with a stick, piece of wire, strip of metal, or any other convenient thing for a handle. This extemporized impression cup must not impinge upon the borders of the opening, neither should it enter to any extent. With an uniform film of soft plaster of from one sixteenth to one eighth of an inch in thickness laid over this cup, a correct impression can be made without any surplus to give anxiety. Upon a correct plaster cast, taken from such an impression, make a model of the obturator out of gutta-percha, or any other plastic substance, the subsequent steps being in principle the same as in making any other piece of vulcanite. It is desirable that it should enter the perforation and restore as far as possible the lost portion of the palate, but it must not protrude into or in any way obstruct the nasal passage.

The entire freedom of the nasal passage is essential to the purity of articulation.

That portion of the obturator which occupies the oral cavity should be made as delicate as possible, consistent with its strength and durability.

A clumsy contrivance will interfere with articulation almost as much as it is improved by stopping the opening, therefore if the obturator could be confined entirely to the opening, like a cork in a bottle, it would be all the more desirable, but as it cannot, resort must be had to clasping to the contiguous teeth, if there are any, and if not, the obturator must spread out over the whole jaw, and receive its support in the same manner as would a set of artificial teeth. In fact this is just what it would become in such a case, viz., an upper set of teeth bridging over and filling up an opening in the palate, thus combining an obturator with a set of teeth.

Fig. 142 represents an obturator without teeth and with-

Fig. 142.

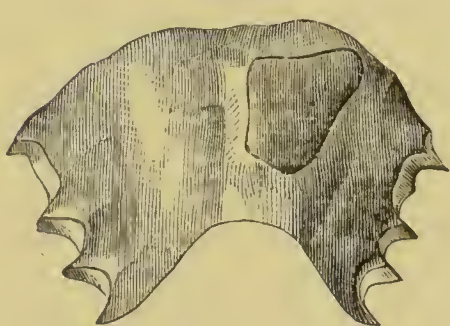
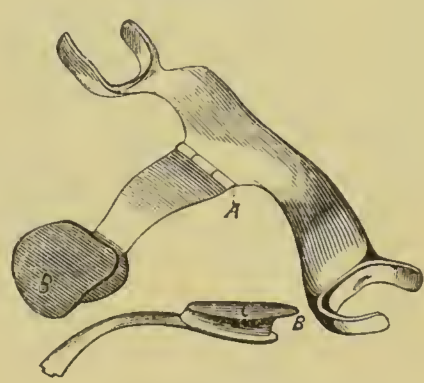


Fig. 143.



out clasps, for a perforation of the hard palate, being sustained *in situ* by impinging upon the natural teeth with which it comes in contact. Accuracy of adaptation and delicacy in form are all that is essential in such cases, and the restoration of the speech will follow immediately.

Fig. 143 represents a more complicated obturator, adapted to an opening in the soft palate.

The necessity for a variation in the plan will be found in the anatomical fact of the constant muscular action of the

soft palate which would not permit, without irritation, the presence of an immovable fixture.

This is contrived therefore, with a joint which will permit the part attached to the teeth to remain stationary, while the obturator proper is carried up or down as moved by the muscles. The joint A should occupy the position of the junction of the hard and soft palates. The joint and principal part of the appliance is made of gold, the obturator of vulcanite. The projection B lies like a flange upon the superior surface of the palate, and sustains it; otherwise the mobility of the joint would allow it to drop out of the opening. This flange is better seen in the side view marked C. It is readily placed in position by entering the obturator first, and carrying the clasps to the teeth subsequently.

Figures 142 and 143 will illustrate the essential principles involved in all obturators. The ingenuity of the dentist will often be taxed in their application, as the cases requiring such appliances all vary in form and magnitude.

Artificial Palates.—Before proceeding to a description of appliances, a brief reference to the anatomical relations and functions of the palate will be necessary. The palate exercises quite as important an office in the articulation of the voice as does the tongue or lips. Being a muscular and movable partition to separate the nasal and oral cavities, one edge is attached to the border of the hard palate, while the other vibrates between the pharynx and the tongue. The voice therefore, as it issues from the larynx is directed by the palate entirely into the mouth, or through the nose, or permitted to pass both ways.

A very slight deviation in this organ from its natural form will make the voice give a different sound. So will also the presence of anything that clogs the natural passages either oral or nasal.

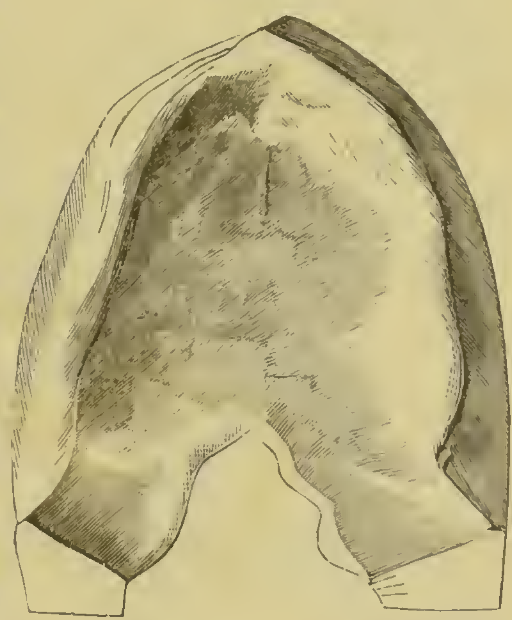
Place any obstruction in the nasal passages, paralyze the soft palate, or let it be deficient in size, and the power of distinct articulation is wanting.

The evidence of this statement is frequently found after the surgeon has successfully performed the operation of staphyloraphy in case of congenital fissure.

In such instances (with rare exceptions) the newly formed palate is so deficient in length, and so tense, as to be deprived of its function. It cannot be raised so as to meet the pharynx and shut off the nasal passage, but hangs like an immovable septum to divide the column of sound.

Fig. 144 represents a defective palate belonging to the first class; the uvula and a portion of the soft palate contiguous being destroyed by disease. In such a case an obturator would be useless, the constant activity of the surrounding parts would not tolerate it. The material used for a substitute must be soft, flexible and elastic, and the elastic vulcanite is admirably adapted to this purpose.

Fig. 144.



By observing the cut, (Fig. 144) it will be seen that a portion of the soft palate along the median line remains, and consequently there will be considerable muscular movement which must be provided for, and which may be taken advantage of. It is desirable to make this movement available in using an artificial palate, as thereby more delicate sounds are produced than otherwise.

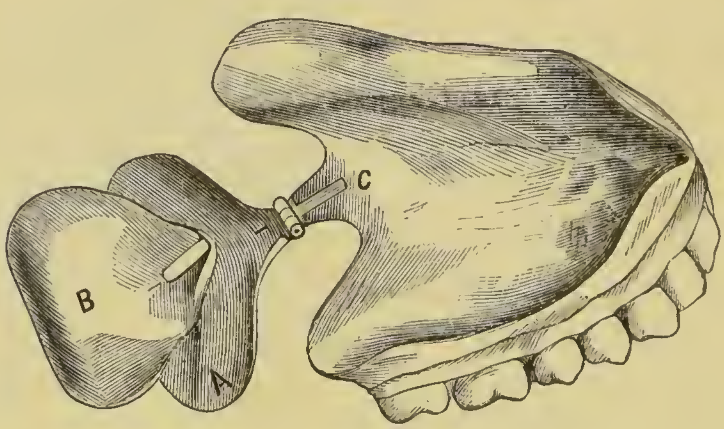
This case presents some extraordinary difficulties, in the fact that all the teeth of the upper jaw have been extracted, and it was necessary, therefore, to adapt a plate which should, not only sustain teeth for mastication, but bear the additional responsibility of supporting the artificial palate. In

the choice of material best adapted for the base for the teeth in such instances, it is preferable to adopt that which will prove the most durable. There are too many interests involved to risk the adoption of anything but the best. In the case under description, the patient desired duplicates, and two sets of teeth were made; one on gold and the other on platina with continuous gum.

The plates were made like other sets of teeth, with the exception of a groove located on the median line at the posterior edge to receive the attachment for the palate, (marked C in Fig. 145).

Fig. 145 will indicate the set of teeth with palate attached. The wings marked letters A and B are made of soft rubber;

FIG. 145.



the frame to support them is made of gold, with a joint to provide for the perpendicular motion of the natural palate, as in the case of the obturator represented in Fig. 143.

When the artificial palate is in use, the joint and frame immediately contiguous lie close to the roof of the mouth; the rubber wing, letter A, bridges across the opening on the inferior surface or side next the tongue; the wing, letter B, bridges across the opening on the superior or nasal surface, and is also prolonged backward until it nearly touches the muscles of the pharynx when they are in repose.

Both these wings reach beyond the boundary of the opening and rest on the surface of the soft palate for a distance of

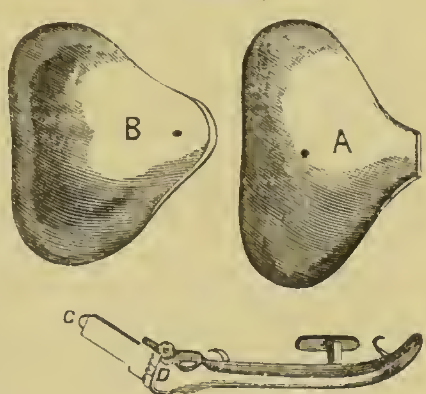
from one-eighth to one-quarter of an inch, thus embracing the entire free edge of the soft palate. This last provision enables the natural palate to carry the artificial palate up or down, as articulation may require.

When the organs of speech are in repose, there is an opening behind the palate sufficient for respiration through the nares. When these organs are in action, a slight elevation of the palate, or a contraction of the pharynx, will entirely close the nasal passage and direct all the voice through the mouth. The palate thus becomes a valve to open or close the nares, and to be tolerated must be made with thin and delicate edges which will yield upon pressure. An instrument thus made will restore, as far as is possible by mechanism, the functions of the natural organ.

In the case under description the patient was a lady, the defect had existed for seven years before remedy. Articulation was very defective; distinct and perfect articulation followed within one month.

Fig. 146 represents the artificial palate separated into its constituent parts. The frame is bent at the joint, in the engraving, to show a stop, marked D, which prevents the appliance from dropping out of position. Letter C shows the tongue which enters the groove in the plate of teeth and connects them. Letters A and B are the rubber flaps, which are secured to the frame by the hooks as seen in the engraving.

Fig. 146.



The process for making the rubber wings will be found described on page 427.

Fig. 147 shows a more extensive palatine defect of the first class. In this case the entire soft palate is gone, together with a small portion of the hard palate at the median line.

Although this defect is greater in extent, the means for its

remedy are more simple. The muscles of the palate are entirely gone, and consequently no perpendicular movement need be provided for.

The appliance in this case will resemble an elastic obtura-

Fig. 147.

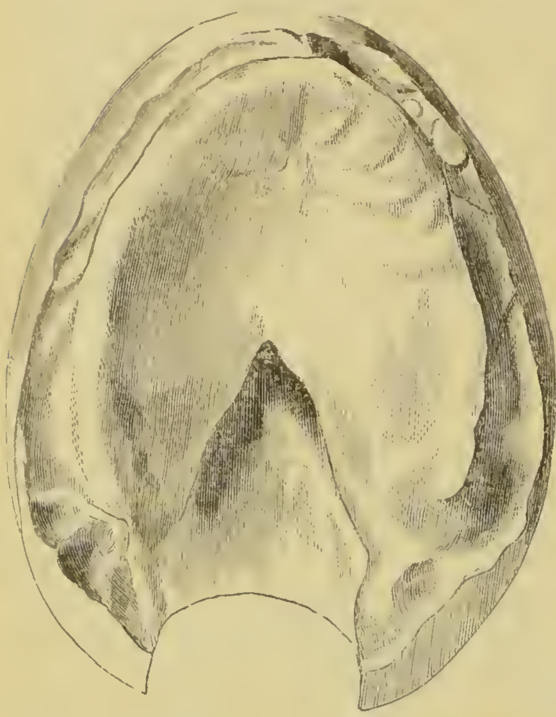
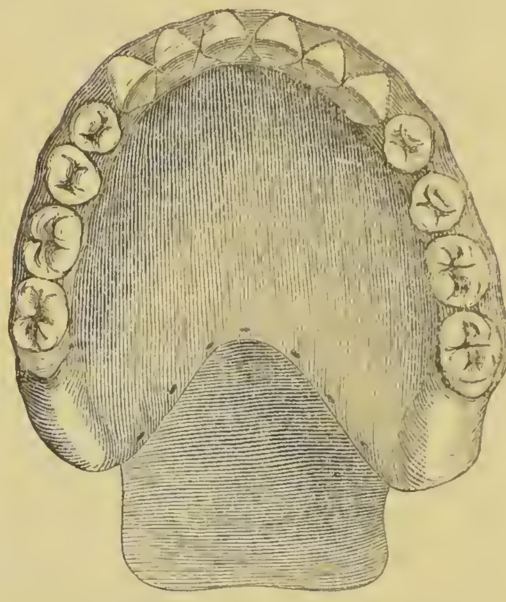


Fig. 148.



tor more than the valve-like palate of the preceding one. The principle here adopted will be substantially that recommended by Mr. Sercombe of London, some ten years since, and consists of a plate with a set of teeth in the usual form, and attached to its posterior edge an apron of soft rubber, which shall bridge the opening on its inferior surface, extending nearly to the pharynx. Fig. 148 represents the set of teeth with the palate attached. In Mr. Sercombe's appliance this apron was made of the common sheet rubber in the market, prepared for other uses, and is objectionable for two reasons. 1st, a want of purity in the materials of which it is compounded; in many instances substances being used in its manufacture which would prove deleterious to the health of the patient; and 2d, its uniformity of thickness. It is far preferable, therefore, to make a mold which

will produce a palate of pure and harmless materials, and which shall be of sufficient thickness in the central part, and at its anterior edge, to give it stability, and shall have a thin and delicate boundary wherever it comes in contact with movable tissue. Such a palate may be made in a mold by substantially the same process as hereinafter described. (See page 427). It may be secured to the plate by a variety of simple means. One which will give as little trouble to the patient as any other, is to make a series of small holes along the edge of the plate and stitch it on with silk, or fine platina, gold, or silver wire may be used.

It is desirable to have the plate and palate present a uniform surface on the lingual side. In fitting the plate, therefore, it may be raised along the posterior edge from the sixteenth to the tenth of an inch, according to the thickness of palate desired. The rubber will thus be placed on the palatine surface of the plate and present uniformity on the lingual surface.

A little thought will show that in this case the patient must educate the *muscles of the pharynx alone*, to do the work of shutting off the nares, which in the former case was performed by them in conjunction with the muscles of the palate. Perfection of articulation will therefore depend upon the success of the patient in this new use of these muscles.

In cases of accidental lesions of the palate, such as are under consideration, this education of the muscles to a new work will not be difficult. The patient at some former time has had the power of distinct articulation; his ear has recognized in his own voice the contrast between his present and former condition, the ear will therefore direct and criticise the practice until the result is attained.

In the case illustrated by Figs. 147 and 148, the defect had existed for 28 years, the patient at the time of the introduction of the artificial palate being nearly fifty years of age. The effect upon the speech was instantaneous. Articulation was immediately nearly as distinct as in youth, and this remarkable distinctness can only be accounted for upon the

assumption that the pharyngeal muscles had undergone a thorough training in the vain effort to articulate without any palate.*

The two cases chosen to illustrate the application of artificial palates in accidental lesion, have required, as will have been perceived, entire upper sets of artificial teeth in connection with the palates. This selection was purposely made because the difficulties to be overcome are much greater. In cases where there are natural teeth remaining in the upper jaw, the palate and its connection with a plate would be substantially the same, and the plate might easily be secured to the teeth by clasps in the same manner as a partial denture.

Artificial Palates for Congenital Fissure. — Congenital fissure of the palate presents far greater difficulties to be overcome than cases of accidental lesion. The opening is commonly more extensive, the appliance more complicated, and the result more problematical. Nevertheless, appliances have been made in a large number of cases, which have enabled the wearer to articulate with entire distinctness, so much so as not in the least to betray the defect. The first efforts in this direction were of the character of obturators, simply plugs to close the posterior nares, and the results were far from satisfactory. It was not until it was recognized that the two classes of cases (accidental and congenital) were entirely distinct, that much progress was made.

Nearly every case of accidental lesion can be treated with an obturator with considerable success; very rarely will an obturator be of any benefit in congenital fissure, even if the congenital and accidental case present substantially the same form of opening. For this reason so much mystification has been thrown around these appliances within a few years past. The character of the different classes has been confounded, and an instrument admirably adapted to one class has had claimed for it an equal application to the other class. Let it

* An account of this case appears in the "Argus," of Bainbridge, Georgia, August 1, 1868, written by the patient himself, who is the editor of that paper.

be understood therefore, as a rule to which there will be but few exceptions, that congenital fissure of the soft palate requires for its successful remedy a soft, elastic, and movable appliance, and that when the most skillfully made and adapted instrument is worn, *articulation must be learned*, like any other accomplishment. Various inventions have been made for this purpose within the last twenty-five years, from the most complicated one of Mr. Stearns, described in the first edition of this work, to the extreme of simplicity of bridging the gap with a simple flap of rubber. The Stearns instrument, with all its complexity, embodied the only true principle, viz., the rendering available the muscles of the natural palate to control the movements of the artificial palate.

The essential requisites of an artificial palate will be, to restore as far as possible the natural form to the defective organs with such material as shall restore their functions. Muscular power, certainly, cannot be given to a piece of mechanism, but the material and form may be such that it will yield to and be under the control of the muscles surrounding it, and thus measurably bestow upon it the function of the organ which it represents.

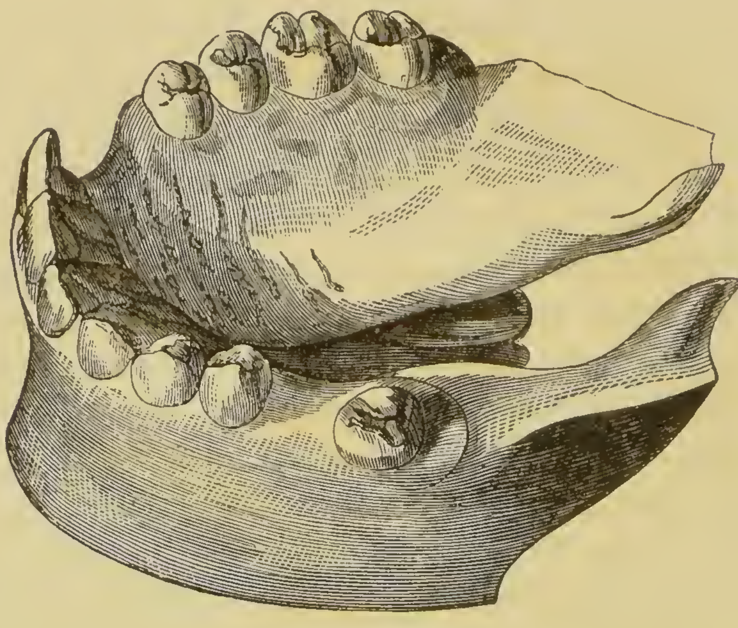
Fig. 149 represents a model of a fissured palate, complicated with hare-lip on the left of the mesial line. There is a division also of the maxilla and the alveolar process, the sides being covered with mucous membrane which come in contact with each other, but are not united. The left lateral incisor and left canine tooth are not developed.

Fig. 150 represents the artificial velum, as viewed from its superior surface, together with the attachment and two artificial teeth to fill the vacancy.

The lettered portion of this appliance is made of elastic vulcanized rubber; its attachment to the teeth of hard vulcanized rubber, to which the velum is connected by a stout gold pin, firmly imbedded at one end in the hard rubber plate. The other end has a head, marked C, which being considerably larger than the pin, and also the corresponding hole in the

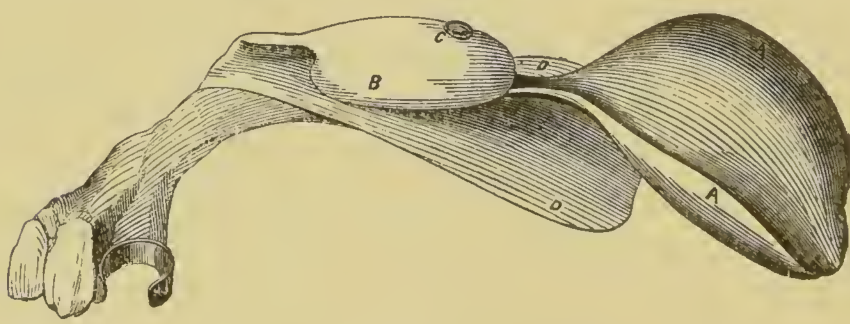
velum, it is forced through—the elasticity of the velum permitting—and the two are securely connected.

Fig 149.



The process, B, laps over the superior surface of the maxilla, (the floor of the naris,) and effectually prevents all inclination to droop.

Fig. 150.

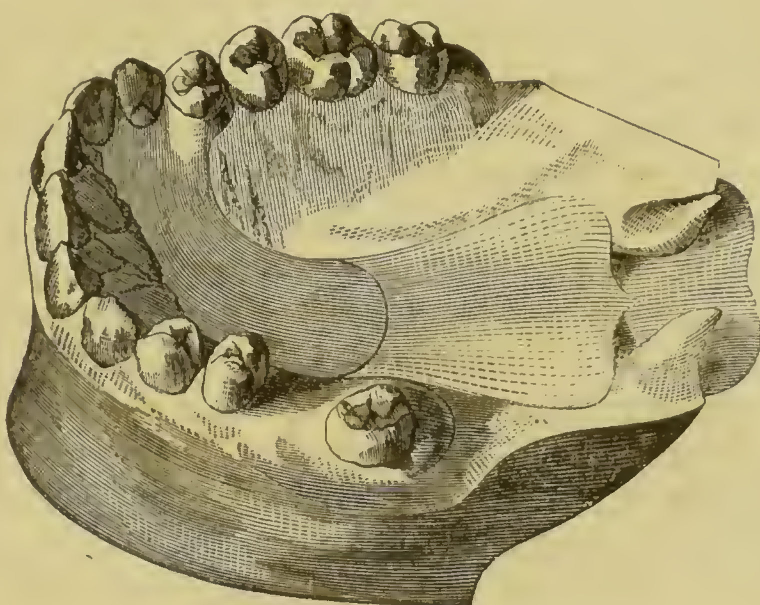


The wings, AA, reach across the pharynx, at the base of the chamber of the pharynx, behind the remnant of the natural velum.

The wings, DD, rest upon the opposite or anterior surface of the soft palate.

Fig. 151 represents a model, the same as Fig. 149, with the appliance, Fig. 150, *in situ*.

Fig. 151.



The wing DD, in Fig. 150, and the posterior end of the artificial velum only in this cut being visible.

Method of Making an Artificial Palate.—The success of these appliances depends very much upon the accuracy of the model obtained to work by.

It is essential that the entire border of the fissure from the apex to the uvula should be perfectly represented in the model, as the parts are when in repose. It is also necessary that the model show definitely the form of the cavity above, and on either side of the opening through the hard palate, being that part of the cavity which is hidden from the eye. It is desirable, also, that the posterior surface of the remains of the soft palate be shown, but this is not essential; but it is especially important that the anterior or under surface be represented with relaxed muscles and in perfect repose. The impression for such a model must be taken in plaster, it is the only material now in use adapted to the purpose. An ordinary brittania impression cup may be used, selecting one

in size and form corresponding to the general contour of the jaw. This cup will be found too short at the posterior edge to receive the soft palate, but it may be extended by the addition of a piece of sheet gutta-percha, which must be molded into such form as not to impinge upon the soft palate, but which will reach under and beyond the uvula, and thus protect the throat from the droppings of plaster. Before using the plaster the posterior edge of the gutta-purcha extension may be softened by heat and introduced into the mouth : contact with the soft palate will cause it to yield, so that there is no danger of its forcing away the soft tissues when the plaster is used. With the precaution not to use too much plaster, the first effort will be to get only the lingual surface. After trial, if the impression show definitely the entire border of the fissure, and the soft palate has not been pushed up by contact with the cup, nor pulled up by the spasmodic action of the levator muscles, it is all that is thus far desired. If, however, the soft parts have been disturbed, (which on close comparison a little experience will decide), it is better to cast a model into the impression, and upon this model extemporize an impression cup as described on page 416. This temporary cup will have the advantage of the former, insomuch that it will require but a film of plaster to accomplish the result, thus lessening the danger of disturbing the soft tissues. After the removal, if it is seen that any surplus has projected through the fissure and lapped out to the floor of the nares, it may be pared off.

The next step will be to obtain, in conjunction with this impression of the under surface, which we will call the palatal impression, an impression of the upper or nasal surface of the hard palate.

This can be done by filling the cavity above the roof of the mouth with soft plaster down to the border of the fissure, and while yet very soft, carrying immediately, the palatal impression against it, and retaining it in that position until the plaster is hard, which can easily be ascertained by

the remains in the vessel from which it was taken. With the precaution to paint the surface of the palatal impression with a solution of soap, to prevent the two masses from adhering when brought in contact, there will be no difficulty in removing it from the mouth, leaving the mass which forms the nasal portion *in situ*. With a suitable pair of tweezers this mass is easily carried backward and withdrawn from the mouth, and the irregular surface of contact indicates its relation to its fellow when brought together.

Fig. 152.

Fig. 152 will show such an impression. The portion marked A, B, C, will readily be distinguished as that which entered the nasal cavity. The line of separation from the palatal impression is plainly indicated in the engraving. The groove marked D, shows clearly the impression made by the delicate uvula in the soft plaster. The nasal portion is relatively large, showing an unusually large nasal cavity.

The vomer lies between the projections marked A, A; these projections entering the nasal passages. The surfaces marked B, B, came in contact with the middle turbinated bones—the surface marked C, in contact with the inferior turbinated bone. In many instances these turbinated bones are so large as to nearly fill the nasal passages.

The method of obtaining the model of the jaw from the impression, does not require any particular description. The process is similar to the making of a cast into any other mouth impression.

The model represented in Fig. 149, shows a convenient form for such a cast.

When the nasal portion of the impression does not indicate the superior surface of the soft palate, the part may be re-

presented in the cast by carving. It is not essential to the success of the instrument to be made, that the posterior surface of the soft palate should be represented with the same accuracy that is required of the inferior surface, or of both surfaces of the hard palate. By the aid of a small mirror and a blunt probe, the thickness of the velum, and the depth behind the fissure, can be ascertained and the model carved accordingly.

The portion of the artificial palate coming in contact with it, is so elastic that it easily adapts itself to a slight inequality, rendering absolute accuracy less important.

The next step will be the formation of a model or pattern of the palate. Sheet gutta-percha is preferable for this purpose, although wax, or many other plastic substances might answer.

The form which should be given it is better indicated by the drawing, Figs. 150 and 157, than a written description

Fig 153.

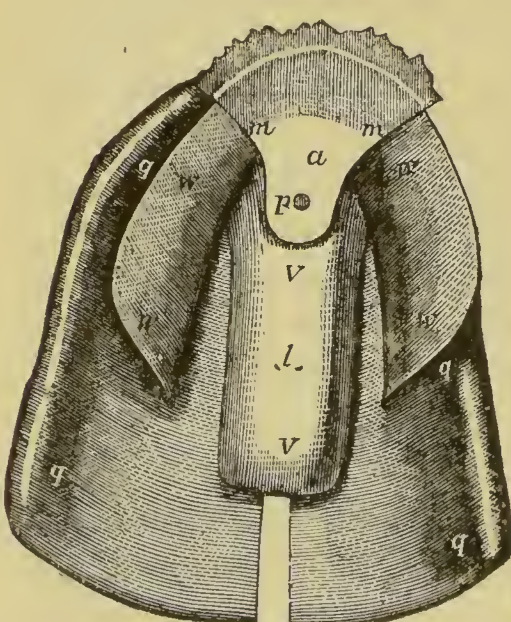
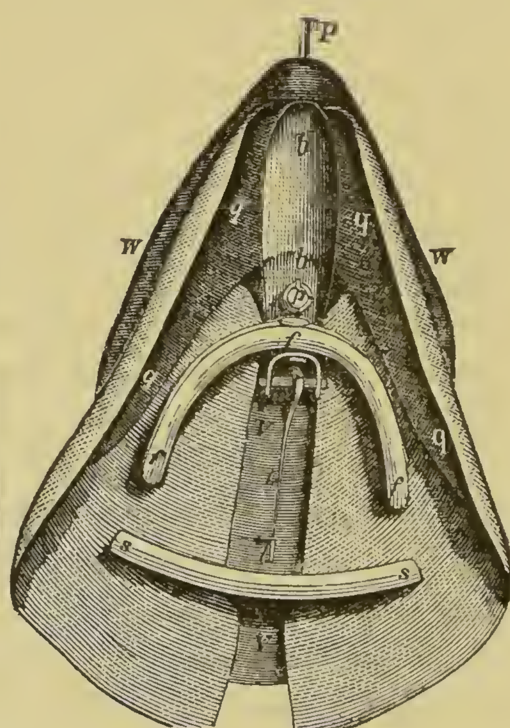


Fig. 154.



would give. The Stearns' instrument of which a cut is here given (Figs. 153, 154), was made to embrace the edges of the

fissure, and was slit up through the middle, so that when the edges of the fissure approached each other, as they always do in swallowing, the two halves of the instrument would slide by each other, and a third flap or tongue was made and supported by a gold spring to cover and keep closed this central slit. This complicated provision for the contraction of the fissure is entirely superseded in Figs. 150 and 157, by making the instrument somewhat in the form of two leaves, one to lie on the inferior and the other upon the superior surface of the palate, and joined together along the median line. When the fissure contracts, the halves of the divided uvula slide toward each other between these two leaves. The posterior portion marked A, in Fig. 150, is made very thin and delicate on all its edges, as it occupies the chamber of the pharynx, and is subject to constant muscular movement.

The sides are rolled slightly upward while the posterior end is curved downward. The inferior portion marked D, D, in Fig. 150, should reach only to the base of the uvula, and bridge directly across the chasm at this point, and no effort to imitate the uvula should be made. The extreme posterior end should not reach the posterior wall of the pharynx when all the muscles are relaxed by a quarter of an inch, although subsequent use must determine whether this space be increased or diminished, thus leaving abundant room for respiration, and the passage of nasal sounds. In cases where it is desirable to make the instrument independent of the teeth, as far as possible, in its support, the anterior part which occupies the apex of the fissure in the hard palate may lap over on to the floor of one or both nares. Such a projection is seen in Fig. 150, marked B, and a like process is seen in Fig. 157, but not lettered. Were it not for this process in this case, the palate would drop out of the fissure into the mouth, the single clasp at the extreme anterior end not being sufficient to keep the whole appliance in place throughout its entire length. Caution must be exercised that this projec-

tion entering the nares be not too large or it will obstruct the passage and give a disagreeable nasal tone to the voice.

All these described peculiarities must be provided for in the gutta-percha model, which after having been carefully formed to the cast, may be tried in the mouth to ascertain its length or necessary variations. When its ultimate form has been decided upon, provision must be made to duplicate it in soft rubber.

A parallel process, and one which will be a familiar illustration, is used when a set of teeth is made on vulcanite base. A model or pattern form is made of gutta-percha, bearing the teeth, and in all its prominent characteristics is shaped as the completed denture is desired; the rubber duplicate being vulcanized in a plaster mold. In like manner the rubber duplicate of the palate as before described may be made in a plaster mold.

If plaster is used it must be worked with much care so that the surface shall be free from air bubbles, or the rubber palate will be covered with excrescences that cannot be readily removed. By covering the surface of the mold with collodion or liquid silex, it will be much improved. But ordinarily plaster molds will be found too troublesome for general use. They may be put to a most excellent use, however, by using one to make a duplicate of the gutta-percha in hard rubber.

This is not necessary with those who have had much experience, but with beginners it will be difficult to work up the gutta-percha as nicely as may be desired; a duplicate of vulcanite will enable the operator to make a more artistic model of the palate, and one which can be handled with greater freedom.

As in the course of a life-time a considerable number of elastic palates will be required, the mold which produces them should be made of some durable material. The type metal of commerce is admirably adapted to this use. The most complete mold is one made of four pieces, which will

produce a palate of one continuous piece. Such a mold requires very nice mechanical skill in fitting all the parts accurately, and unless the operator has had experience in such a direction it is better to simplify the matter. By making the palate in two pieces, to be joined after vulcanizing, the mold may be made in two pieces and with very little trouble.

Fig. 155.

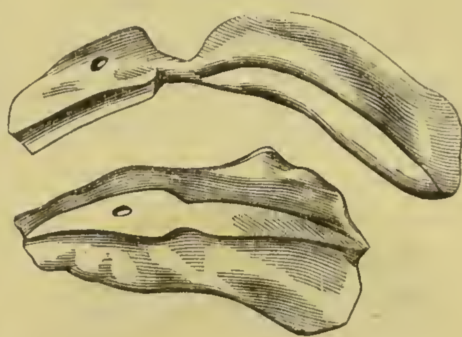
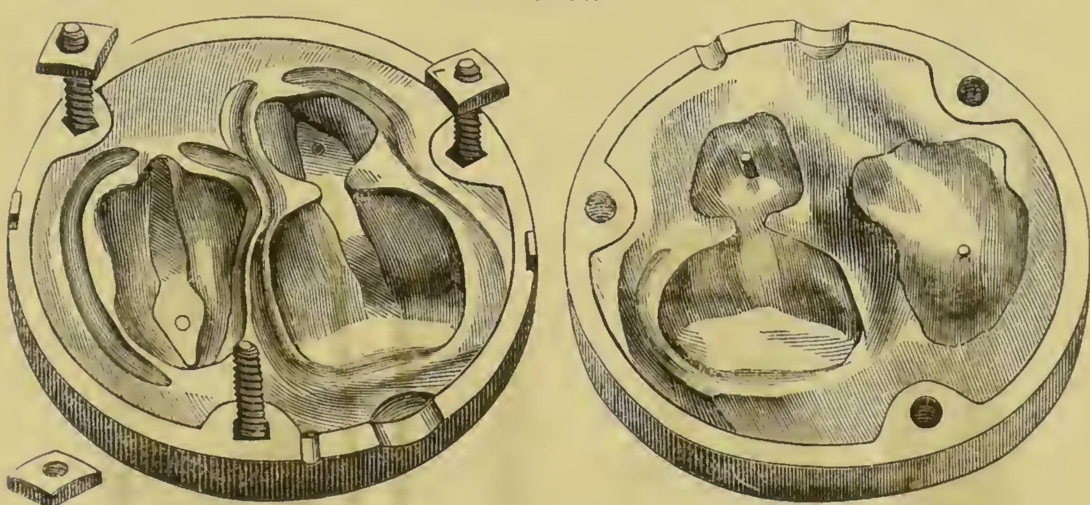


Fig. 155 shows a palate divided.

Fig. 156 shows the mold or flask in which it is vulcanized. These flasks were made expressly for this purpose, but they

Fig. 156.



are not so unlike the flasks in common use in dentists' laboratories, that the latter will not answer. The common flask is simply unnecessarily thick or deep.

The mold is readily produced in the following manner. Imbed the two pieces of the palate in plaster, in one-half of the flask; when the plaster is set and trimmed into form, duplicate it in type-metal by removing the palate, varnishing the surface, molding in sand and casting. In making the sand mold take a ring of sheet-iron of the same diameter of

the flask and 3 or 4 inches high, slip it over the flask and pack full of sand. Separate them, remove the plaster, return the flask to the sand mold, and fill with the melted metal through a hole made in the side or bottom of the flask. With one-half thus made, substantially the same process will produce the counterpart.

Fig. 157 shows the palate complete with its attachment to the teeth. The palate is secured to the plate by a pin of gold passing through a hole in the palate of the same size, the head on the pin being larger than the hole is forced through, and thus the two halves of the palate are bound together and joined to the plate.

Fig. 157.

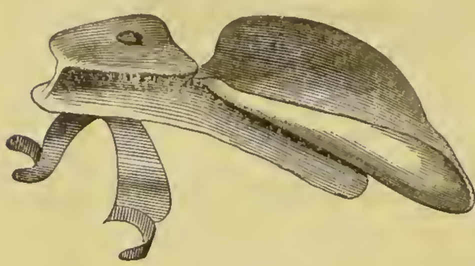
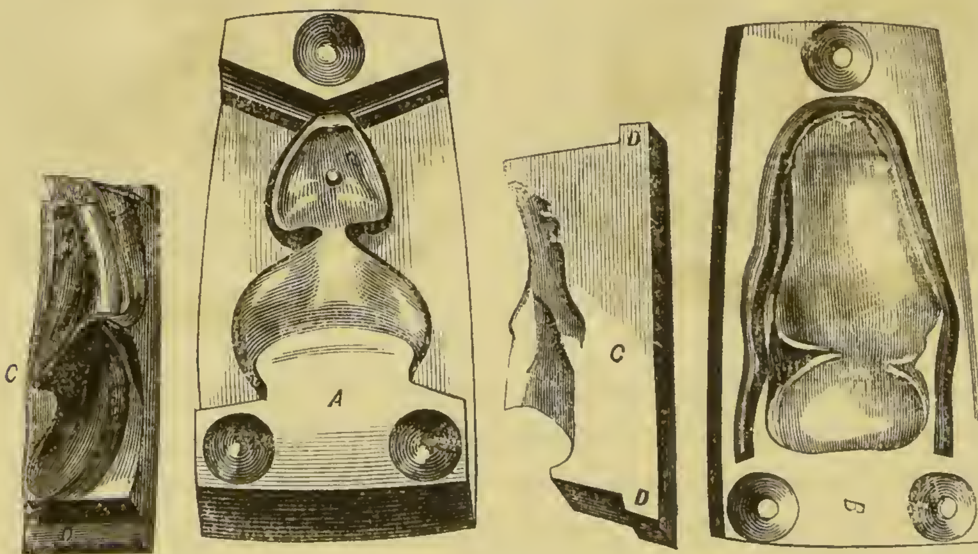


Fig. 158 shows a mold in four pieces. The blocks C, C, are accurately adapted to the body of the mold marked A, and are prevented from coming

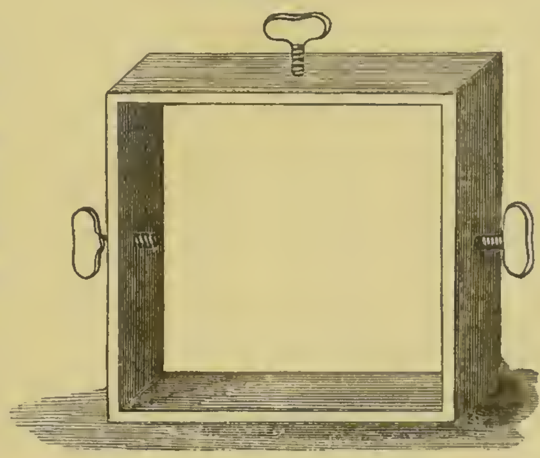
Fig. 158.



improperly in contact with each other by the flanges D, D, which overlap and rest upon the sides of the main piece. B shows the top of the mold, and the groove E, provides for the surplus rubber in packing.

Such a mold makes the most perfect appliance that can be produced. The palate is one, homogeneous, and inseparable piece. The cut will sufficiently indicate the forms of the several parts. Each of these pieces is first made in plaster of exactly the form of which the type-metal is desired. They are then molded in sand and the type-metal cast as in making an ordinary die for swaging. When in use, a clamp similar to Fig. 159, is placed around the mold to keep the several parts firm in their position.

FIG. 159.



The packing of the mold with rubber will be done in the same manner as when hard rubber is used for teeth bases; with which process it is assumed that the operator is familiar. By washing the surface of the mold with a thick solution of soap previous to packing, the palate will be more easily removed after vulcanizing.

The rubber used for this purpose must be a more elastic compound than that used as a base for teeth. The composition used for the elastic fabrics of commerce will answer if made of selected materials.

The American Hard Rubber Co. have recently placed on sale at the dental depots a compound admirably adapted to this purpose. The best results are obtained when the process of vulcanizing is carried from a heat of 230° gradually during 4 or 5 hours up to and terminating at 270°.

INDEX.

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